Designing Sustainable Landscapes for Avian Conservation in the SAMBI area

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Funding and Cooperation

- Funding
  - Multistate Conservation Grant
  - USGS Gap Analysis Program
  - USGS Science Support Project (Development of Inference Methods)
  - USFWS ACJV
- Cooperators
  - NC Cooperative Fish & Wildlife Research Unit
  - AL Cooperative Fish & Wildlife Research Unit
  - Atlantic Coast Joint Venture

Acknowledgements

- Atlantic Coast Joint Venture
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Presentation Outline

- Project overview and objectives
- Identifying conservation priorities
  - Identification of focal species
  - Calculating landscape priorities
  - Selecting focal areas
- Future directions
  - State and transition approach
  - Dynamic occupancy models

Project overview and objectives

Develop methodology and enhance the capacity of states, joint ventures and other partners to assess and design sustainable landscape conservation for birds and other wildlife in the eastern United States.

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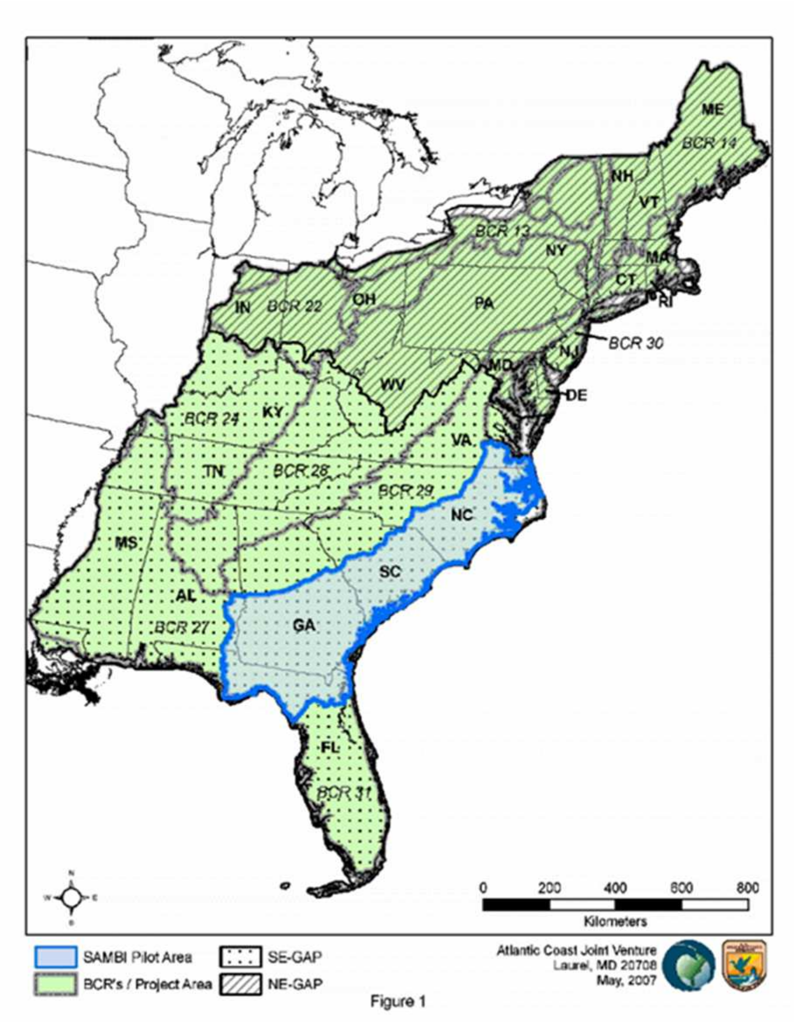
Project Objectives

1. Assess the current capability of landscape to support bird populations
2. Predict the impacts of landscape-level changes (e.g., from urban growth, conservation programs, climate change)
3. Target conservation programs to effectively and efficiently achieve objectives
4. Enhance coordination among partners during the planning, implementation and evaluation of habitat conservation through conservation design

Collaborative approach

- Landscape dynamics – 100yrs (**NCCFWRU & BaSIC**)
  - Climate change (3 Scenarios)
  - Sea level rise (3 Scenarios)
  - Urbanization (1 Scenario)
- Identification of focal species (**ACJV & ALCFWRU**)
- Potential habitat for focal birds (**NCCFWRU & BaSIC**)
- Modeling conservation priorities (**AL CFWRU**)
- Delineating focal areas (**ACJV & AL CFWRU**)

Project Extent



- Pilot Area
  - South Atlantic Migratory Bird Initiative
  - 12 Priority habitats
  - Priority species
  - Population objective
- Potential Expansion
  - SE-GAP Project area
  - NE-GAP Project area*

Identifying conservation priorities

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Approach

- Select focal species for each habitat
- Potential habitat*
- Source populations*
- Suitable sites for each habitat*
  - Landform
  - Geographic constraints
- Constraints on management/restoration*
- Long-term commitment

* Affected by landscape dynamics

Identification of focal species

ACJV
SAMBI
Species List

Expert Elicitation
- Workshops
- Species Associations

Selection method
- Structured Decision Making
- Lambeck (1992)

Expert Review
- Webinar
- Expert review of lists
- Focal species utility

Application to
Habitat priority model

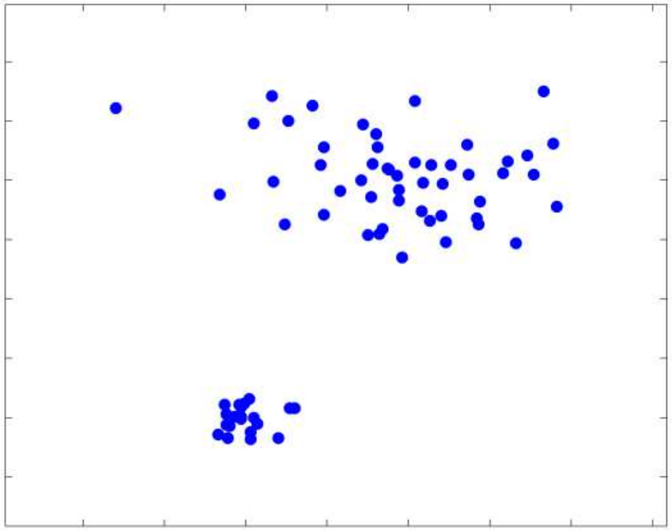
Focal species

1. Acadian flycatcher
2. American black duck
3. American black duck
4. American kestrel
5. American oystercatcher
6. Bachman's sparrow
7. Black-throated green warbler
8. Brown-headed nuthatch
9. Cerulean warbler
10. Chuck-will's-widow
11. Common ground dove
12. Field sparrow
13. Henslow's sparrow
14. Hooded warbler
15. Kentucky warbler
16. King rail
17. Least bittern
18. Least tern
19. Loggerhead shrike
20. Louisiana waterthrush
21. Nelson's sharp-tailed sparrow
22. Northern bobwhite
23. Northern pintail
24. Northern parula
25. Painted bunting
26. Piping plover
27. Prairie warbler
28. Prothonotary warbler
29. Red-cockaded woodpecker
30. Red-headed woodpecker
31. Redhead
32. Redknot
33. Saltmarsh sharp-tailed sparrow
34. Sandhill Crane
35. Seaside sparrow
36. Summer tanager
37. Swainson's warbler
38. Swallow-tailed kite
39. Wood duck
40. Wood duck
41. Wood stork
42. Yellow-throated warbler

Calculating Landscape Priorities

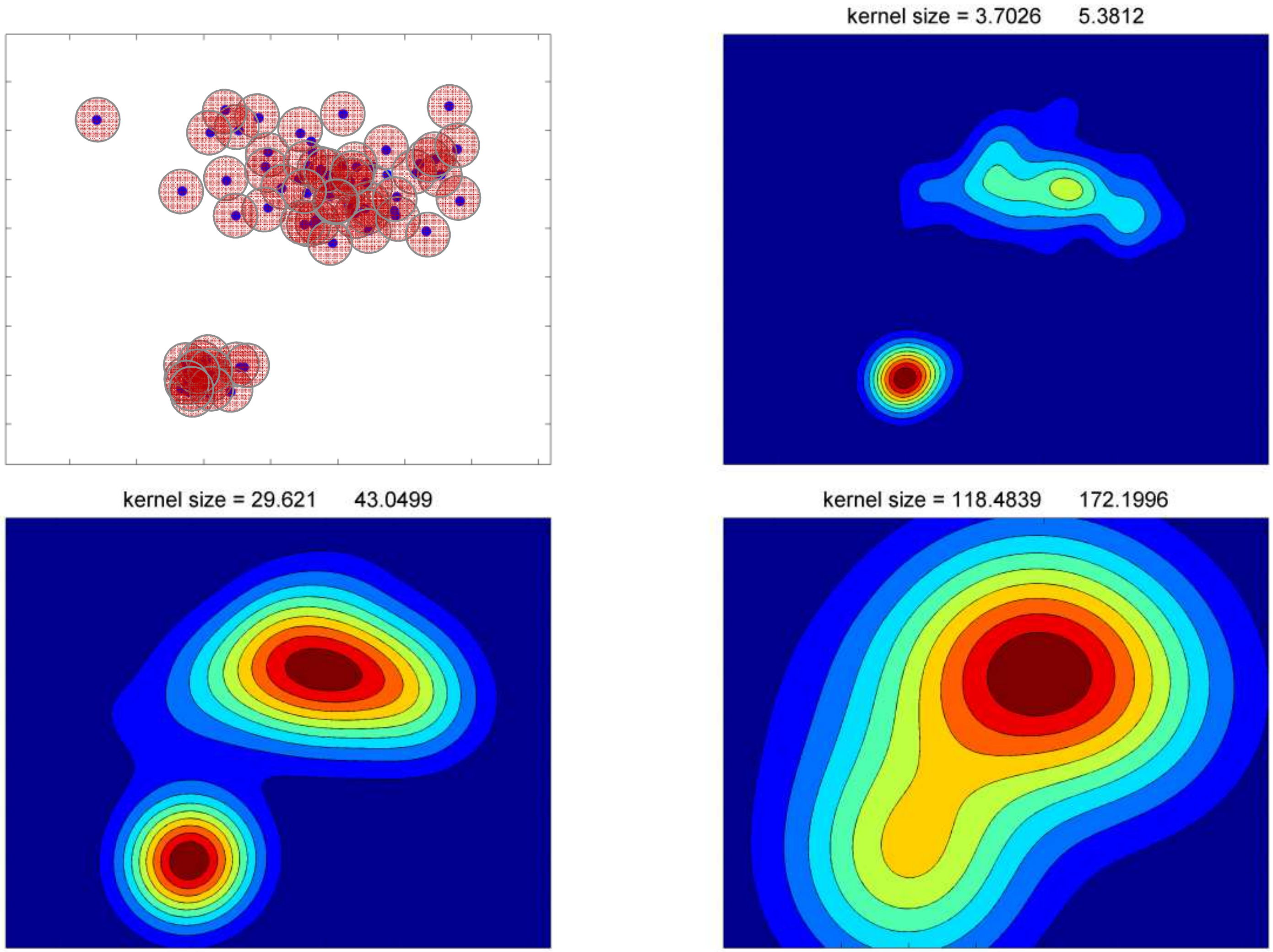
Resource Density

- Nearer to larger patches = ↑ **Density**
- Where density of resources is higher
  - Patch size is larger, rounder
  - Distance to other patches is smaller
  - Fragmentation is less
  - Connectivity is greater



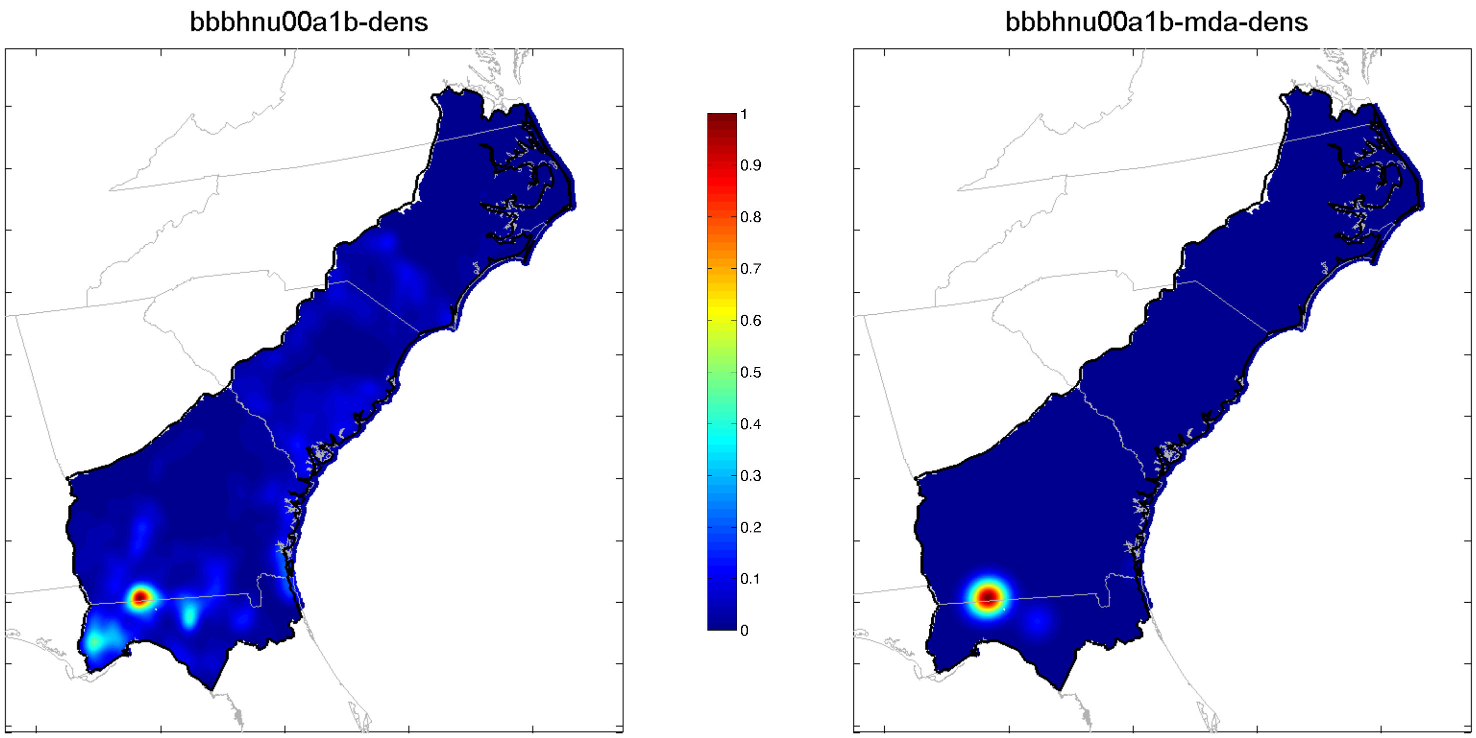
- Diamond (1975) The island dilemma: Lessons of modern biogeographic studies for the design of natural reserves. Biol. Conserv. 7:129-146.

Kernel density



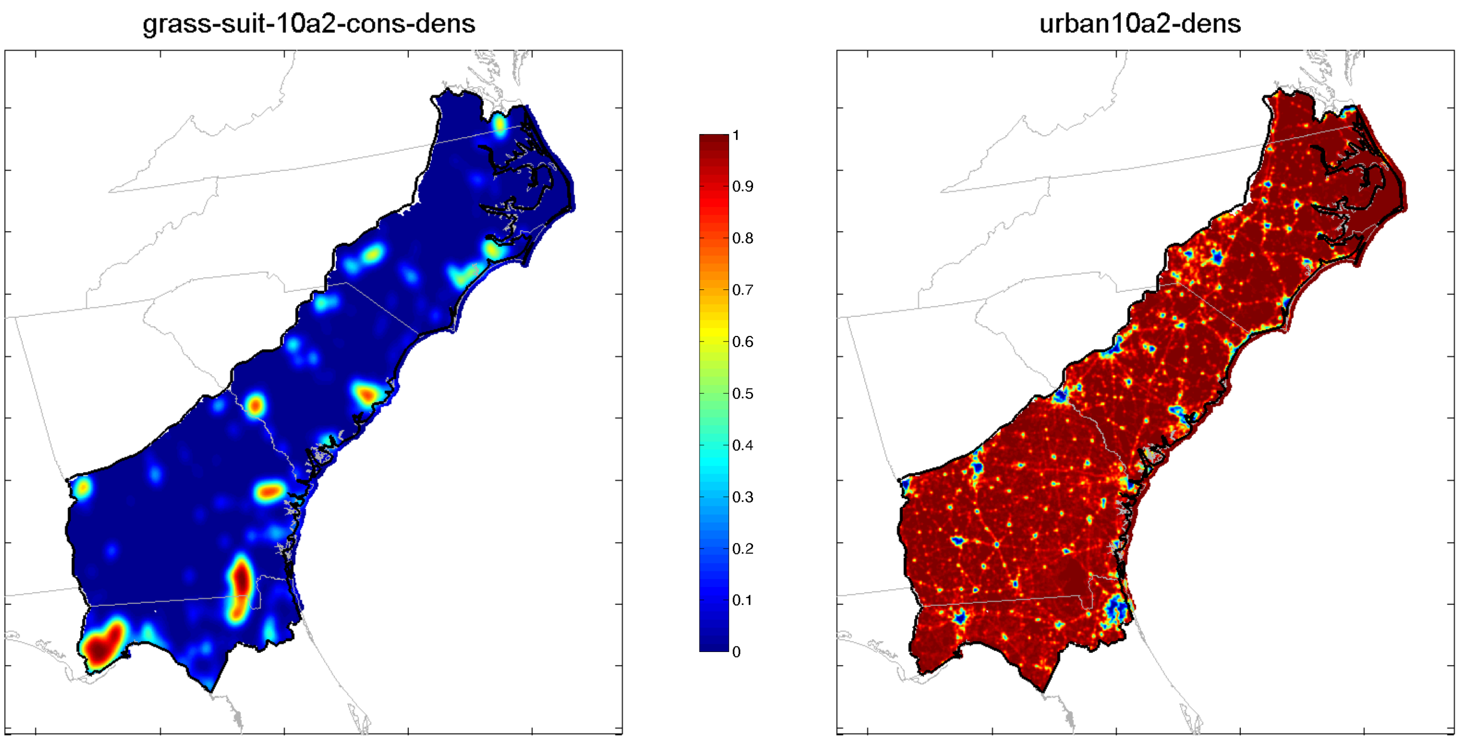
Species-specific data

- Potential habitat – niche space models
- Potential source populations – larger patches



Habitat-specific data

- Suitable sites – land form, hydrology, etc.
- Conservation estate
- Management potential



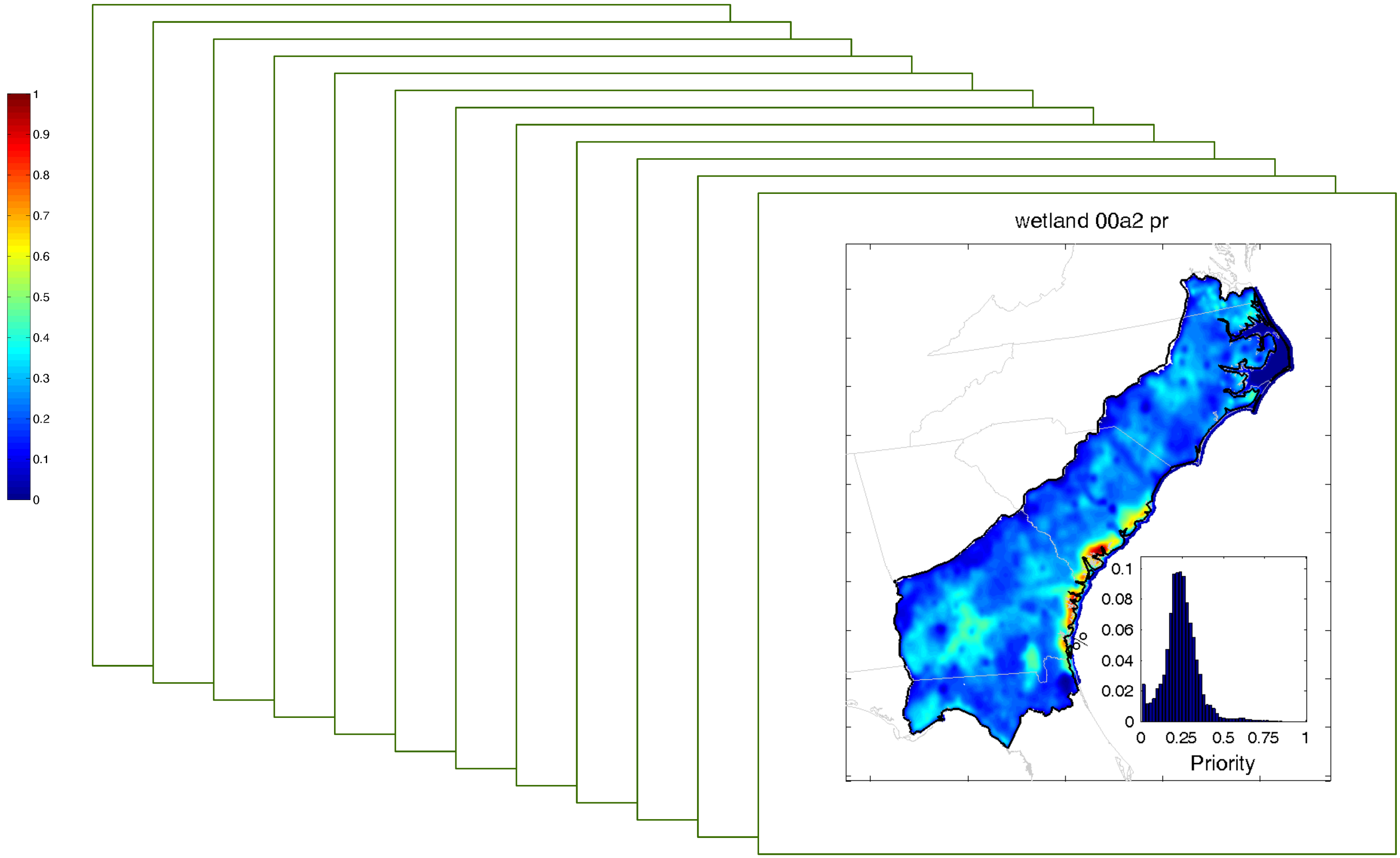
Priority model

Priority = S*F*(P+L+H)

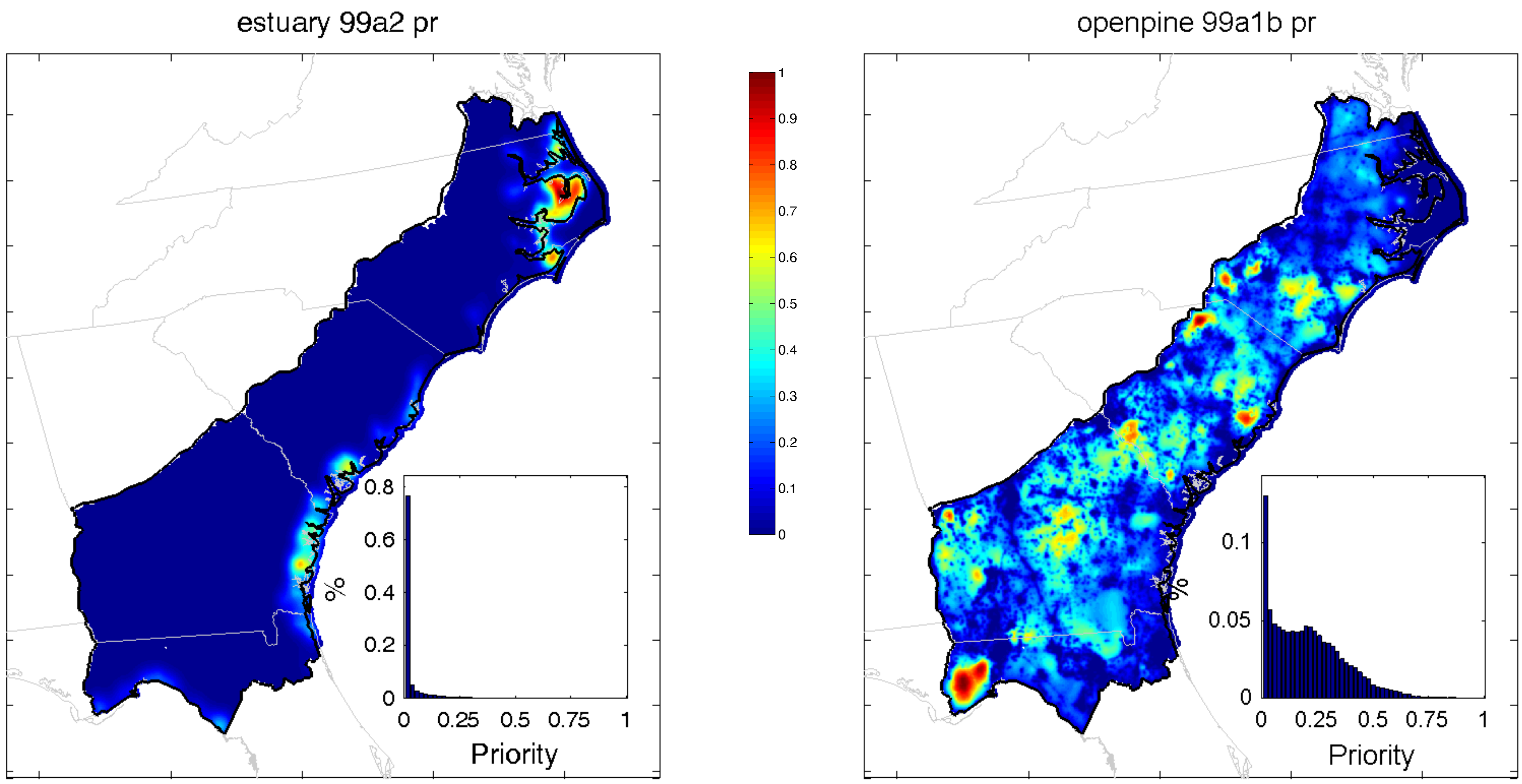
- Combine densities to assign priority

- Limiting factors (*)
  - Density of suitable sites for habitat *x* (S)
  - Potential to manage (F)
- Compensatory factors (+)
  - Density of source populations (P)
  - Density of conservation estate (L)
  - Density of potential habitat (H)

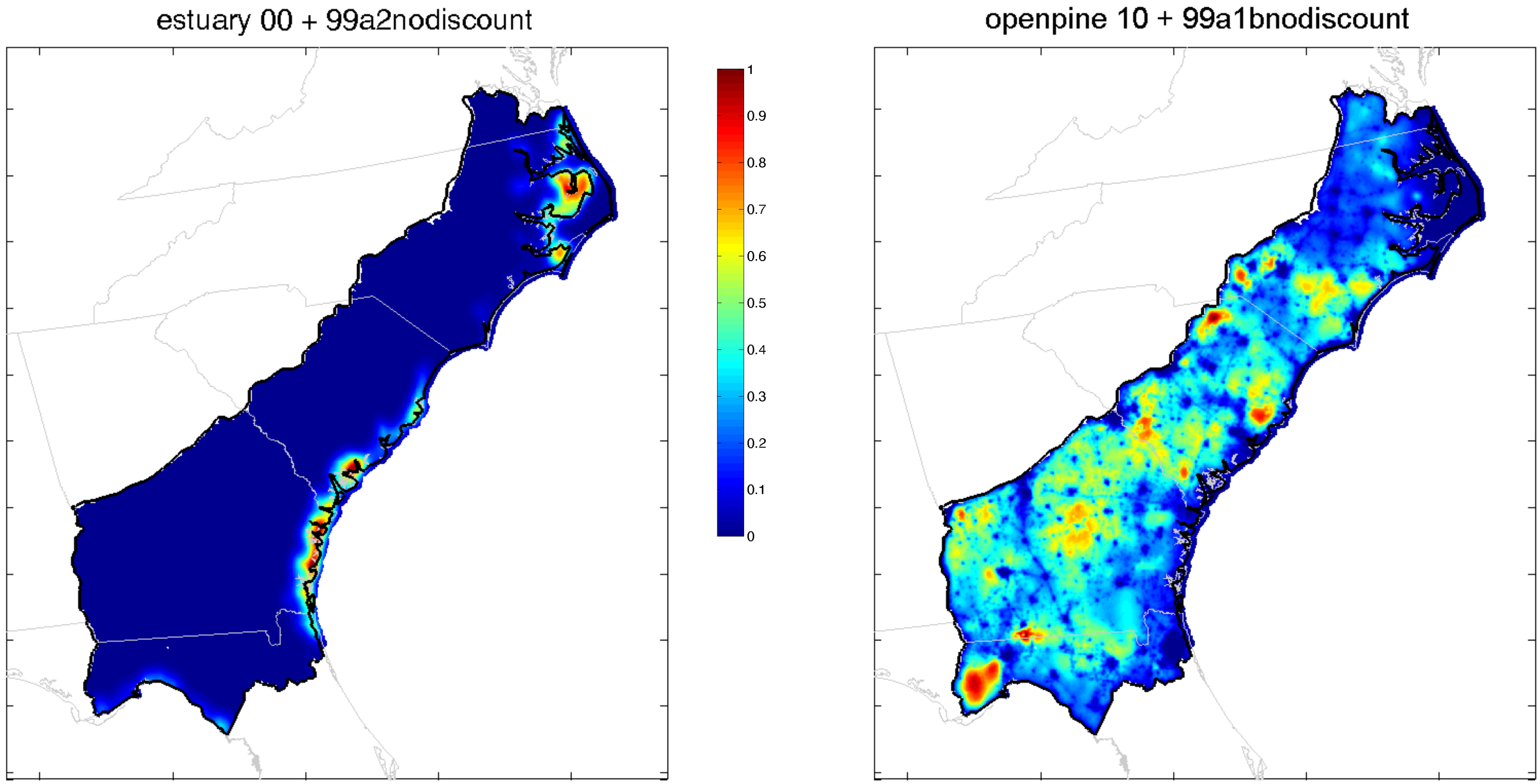
Habitat priorities – current



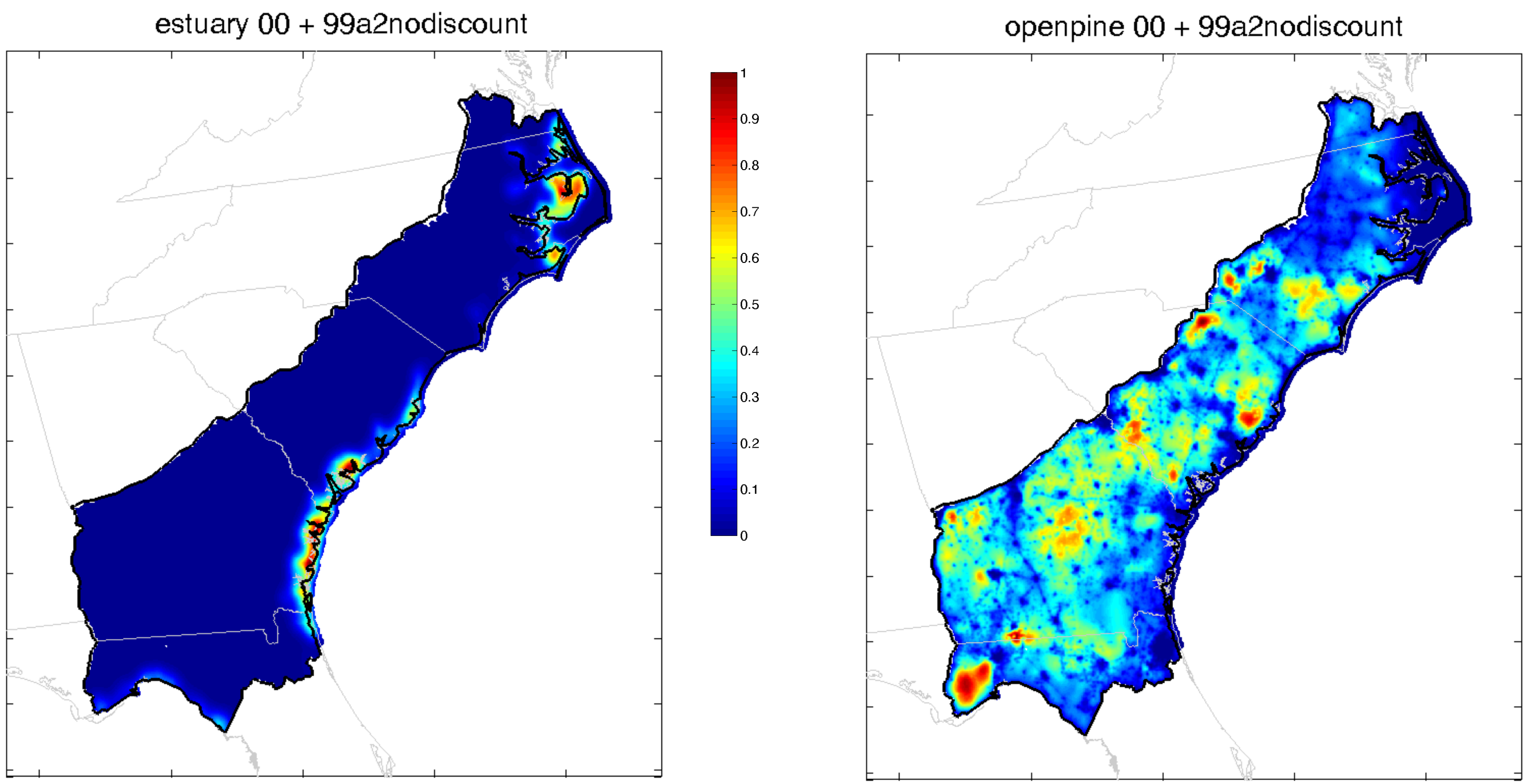
Temporal dynamics



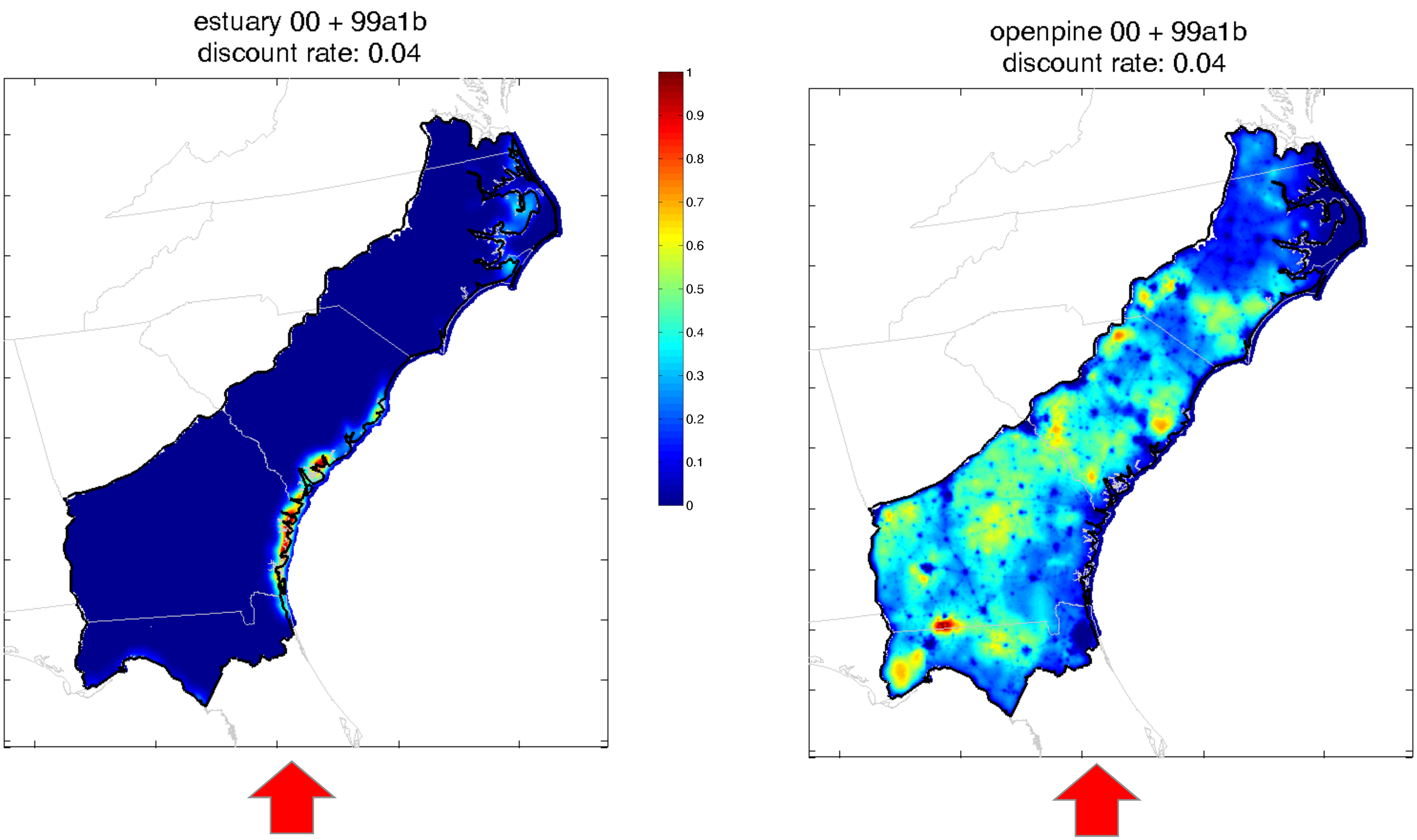
Integrated temporal dynamics



Comparing emission scenarios



Discounting future scenarios



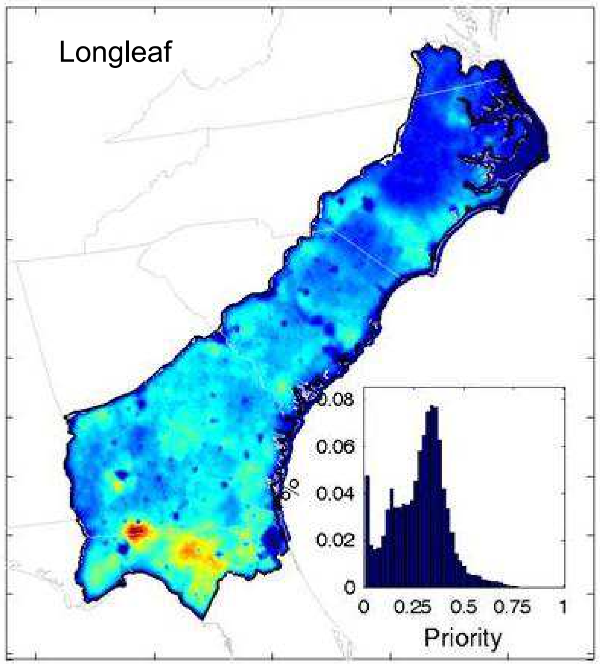
Selecting focal areas

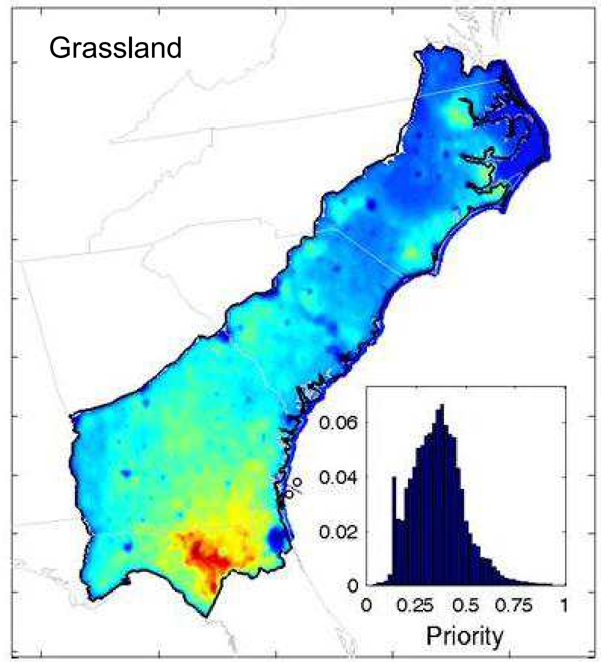
Approach

- Determine area required to meet SAMBI population objectives
  - Use published home ranges or densities
  - Multiplied by population objective
  - Combined species for each habitat
- Delineate 5 sites for each habitat

Approach

What about conflicts?





Priority alternatives

1. Rarity of habitat in SAMBI
2. Rarity of habitat in SAMBI by state
3. Number of imperiled species
4. Most imperiled species
5. Historic extent

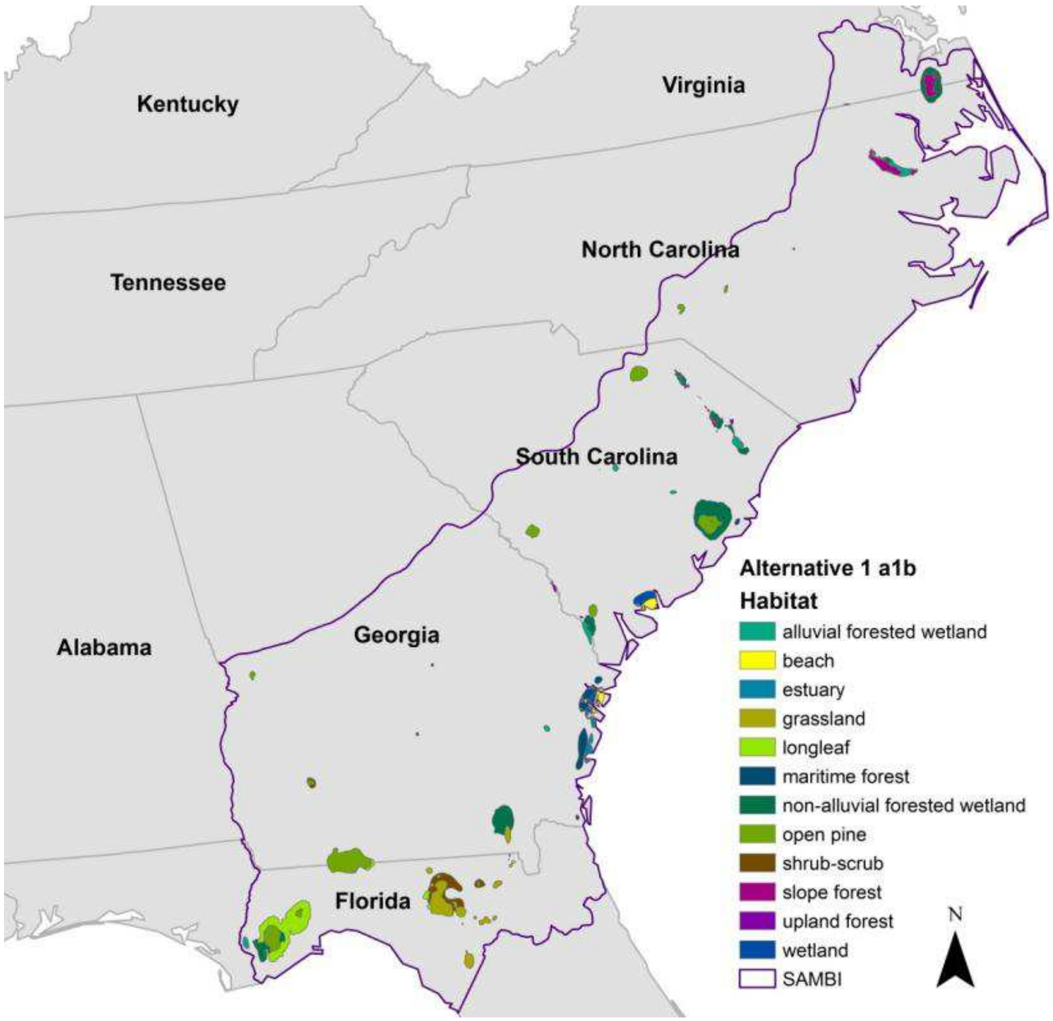
Ranking habitats

	Alternative ranking				
Habitat	1	2	3	4	5
Alluvial forested wetland	12	11	6	5	4
Beach	1	3	2	11	2
Estuary	5	5	7	3	3
Grassland	7	7	10	8	
Longleaf and associated	11	12	5	1	1
Maritime forest	4	4	4	4	7
Non-alluvial forested wetland	9	8	3	10	5
Mature open pine	6	10	11	2	
Shrub scrub	10	6	9	9	
Slope forest	3	2	8	6	7
Upland forest	8	9	12	7	8
Freshwater wetland	2	1	1	12	

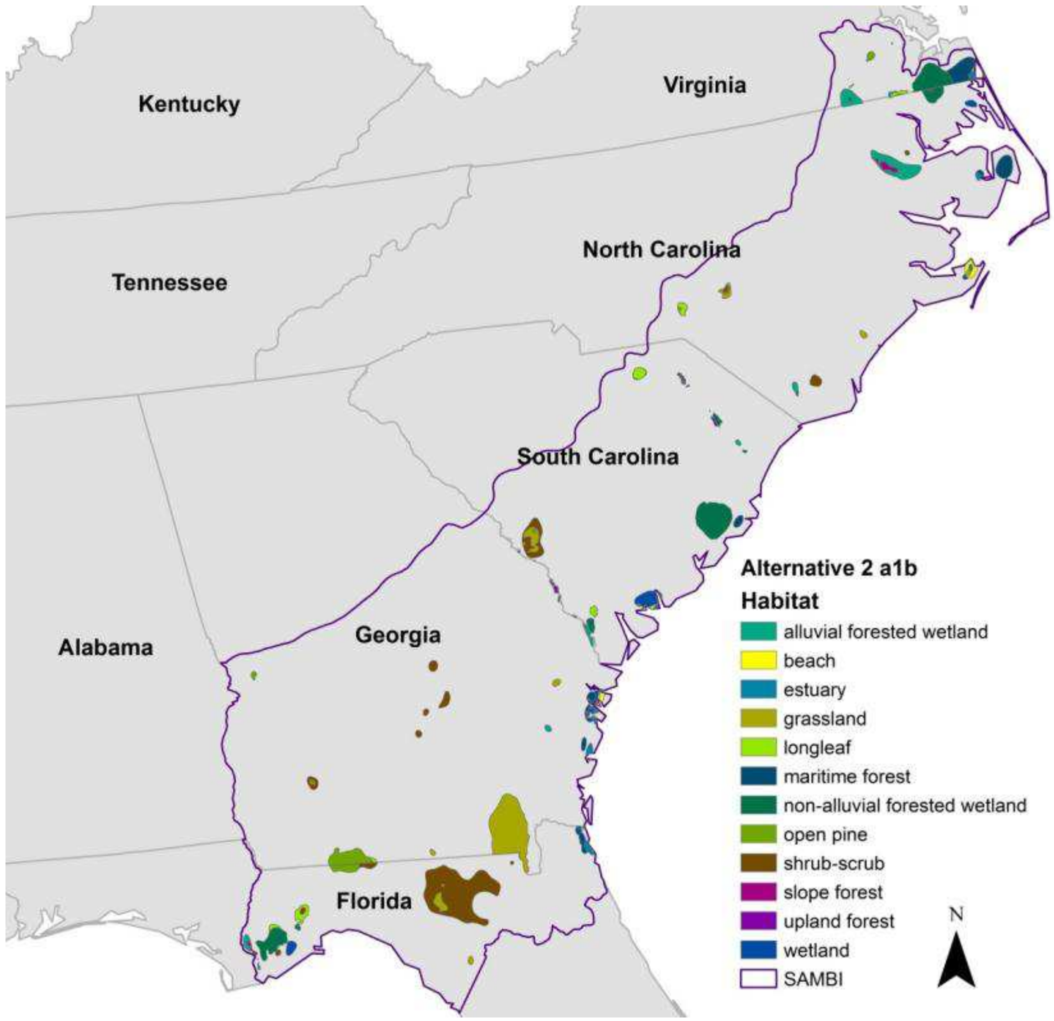
Conflicts

- Start with highest ranking habitat
- Delineate highest priority area
- Mask focal area
- Select next habitat
- Iterate for each habitat

Comparison of alternatives - 1



Comparison of alternatives - 2



Input from ACJV

- What is most important?
- Rarity
  - Species?
  - Habitat?
- Cost?
- States?

Availability of Data

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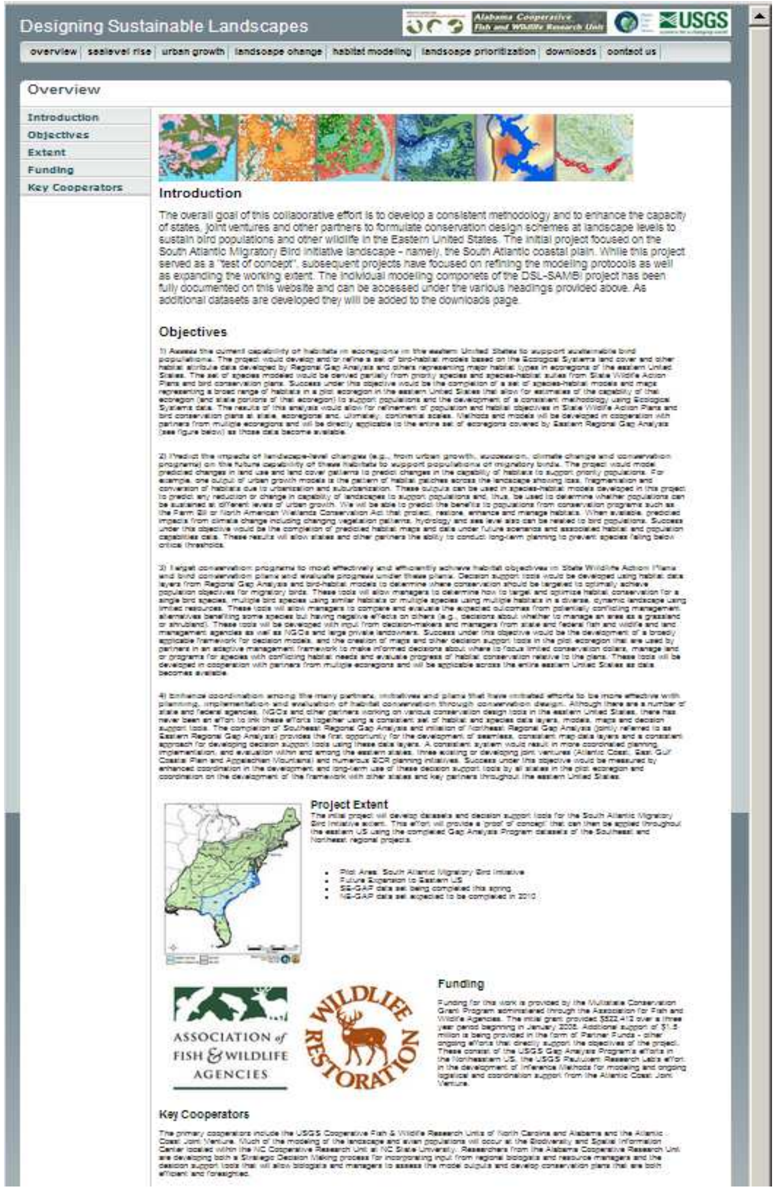
Project website - *www.basic.ncsu.edu/dsl/*

- NCSU
  - Sea Level Rise Modeling
  - Urban Modeling
  - Landscape Succession Modeling
  - Avian Habitat Modeling

  - Occupancy Models and Strategic Habitat Conservation for Avian Species in the Southeastern Coastal Plain of the United States (Monica Iglecia MS Thesis)
- Auburn
- Moody, A.T., 2012. Designing landscapes for bird conservation in the Southeastern United States. (Ph.D. Dissertation)

- Moody, A.T., and J.B. Grand. 2012. Incorporating Expert Knowledge in Decision-Support Models for Avian Conservation in A.H. Perera et al. (eds.), Expert Knowledge and Its Application in Landscape Ecology. Springer.



Future Directions

- Optimal conservation strategies (prototyping)
- Estimating avian range dynamics

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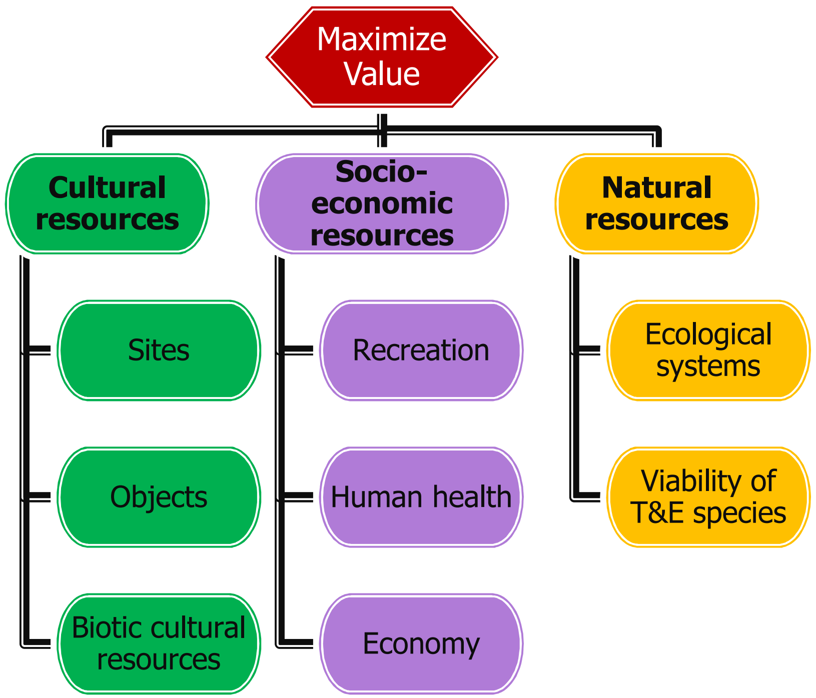
Decisions & Objectives

- What?
  - What actions/strategies?
- When?
  - Does timing matter?
- Where?
  - Does location matter?
- How much?
  - What can we afford?
  - How much is enough?

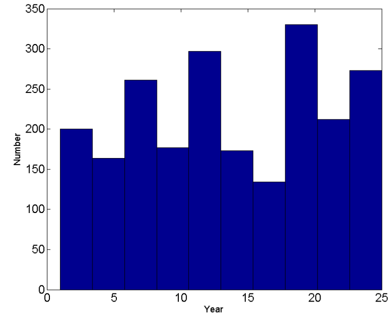


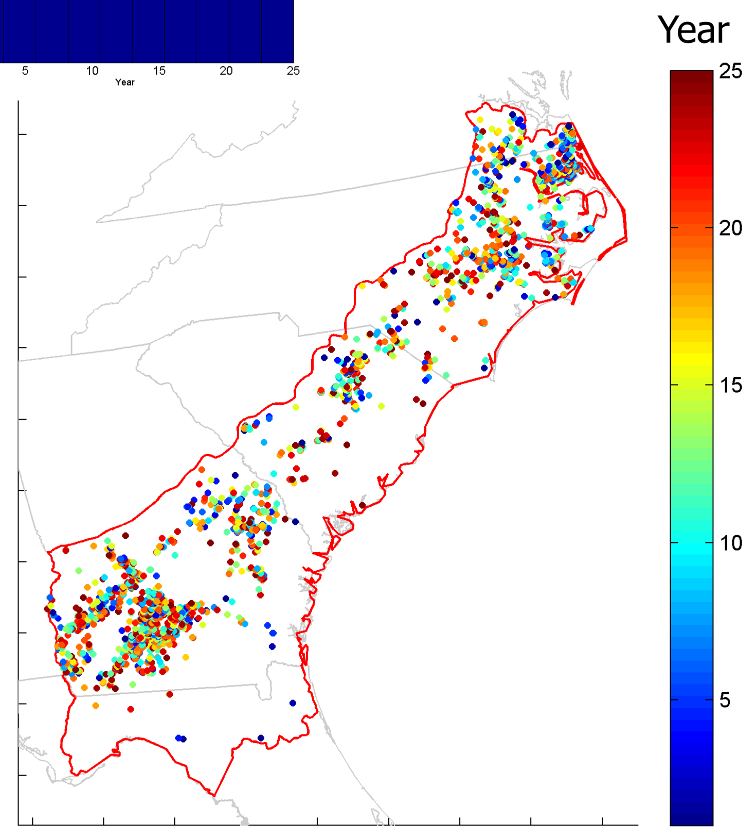
Prototype - Alternatives

- Status quo, business as usual.
- Strategies
  - Select highest valued sites each year in SAMBI
  - Select highest values sites each year in corridors
- Tactics
  - Restore open pine ecosystems
  - Purchase easements to slow land conversion
  - Both

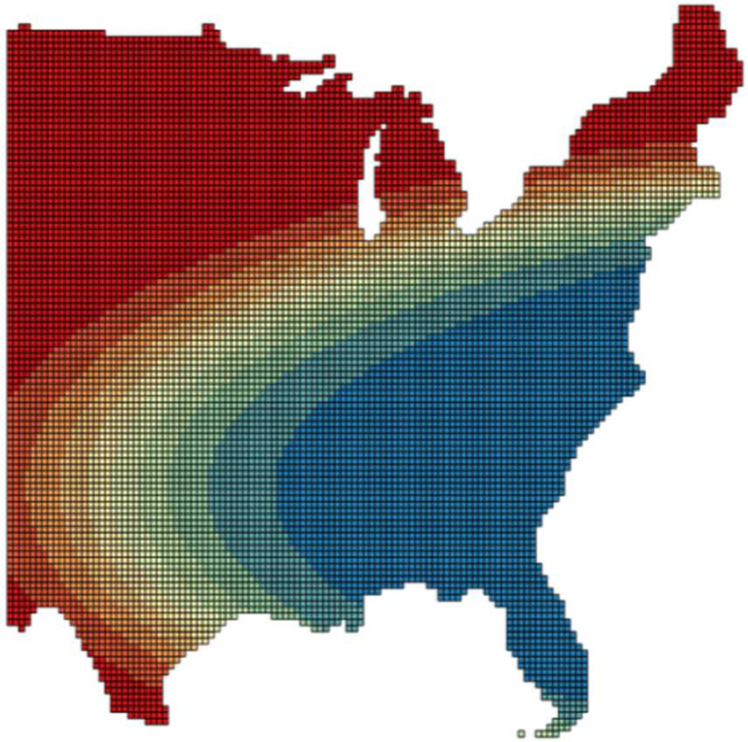
Prototype - Result

- Prioritized list of sites
  - Why?
    - Marginal gains on objectives
  - What?
    - Strategy x Action(s)
  - Where?
    - Higest valued sites
  - When?
    - Based on expected landscape dynamics
  - How much?
    - Constrained by budgets





Avian range dynamics
Dynamic Species Distribution Models



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Dynamic Species Distribution Models

Motivation

- Ecological – quantifying the processes that account for patterns of species distribution…
  - Bridge the gap between mechanistic and static SDMs
    - We showcase a dynamic occupancy approach - single species
    - But models on community dynamics are available

- Inform Decisions – populate a decision model – states, actions, functional form for transitions, rewards and trade-offs…

Modeling species occurrence…

Patch Occupancy (Psi) is defined as the probability that a site is occupied. It adjusts for fact that a species is not always detected with certainty, even when present (*p* < 1)

Notation: ψ_i - probability site *i* is occupied

p_{ij} - probability of detecting the species in site *i* at time *j*, given species is present

The model framework permits relating ψ and *p* to site and/or sampling characteristics via the logistic model (or logit link). Most applicable to this project will be:

Site-specific: model ψ and/or *p*

e.g., habitat type, percent cover, temperature

Prevailing modeling approaches

- Static-based
  - Use current/historical data to develop relationship between species distribution and habitat
  - Use climate change models to project habitat into the future
  - Use above to project bird distribution in the future

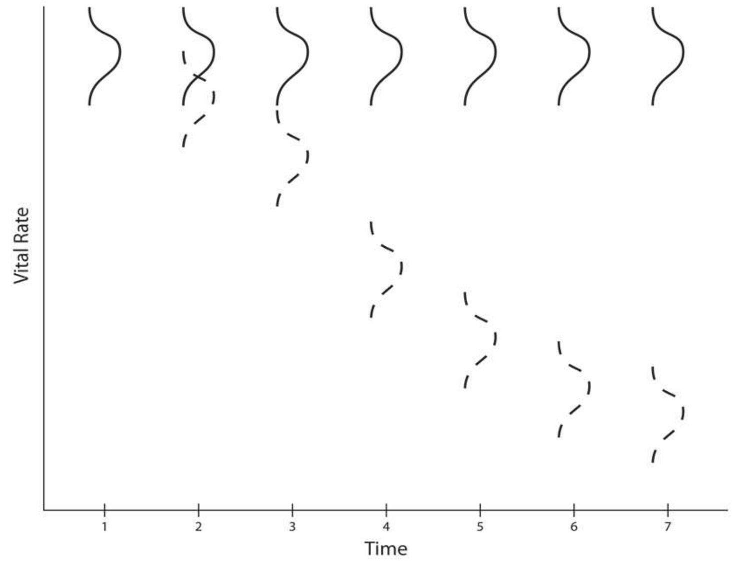
Focus on Dynamics Rather than Statics

- Why might projections based on statics be inadequate?
  - Tacitly based on equilibrium assumption

    - The species-habitat relationship in future is the same as that estimated from current/historical data
    - Observed patterns reflect full biotic potential, thus, species can occupy any "all environmentally suitable locations"
    - The relationship between species distribution and environmental factors at any point in time is not influenced by previous distribution ($\varphi = \gamma$).

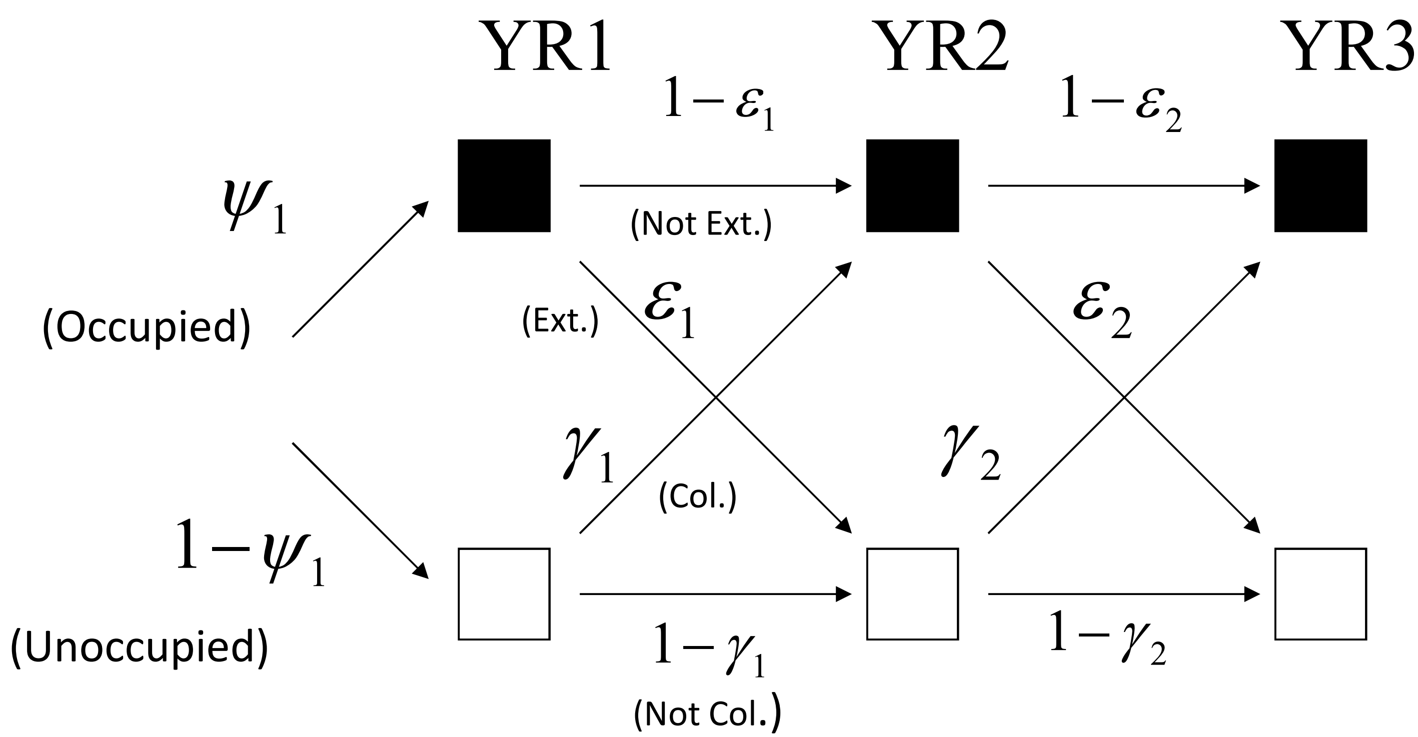
Focus on Dynamics Rather than Statics

- But “Climate Change” is expected to be characterized by nonstationarity, thus, transient dynamics of species and habitat is consistent with this expectation.

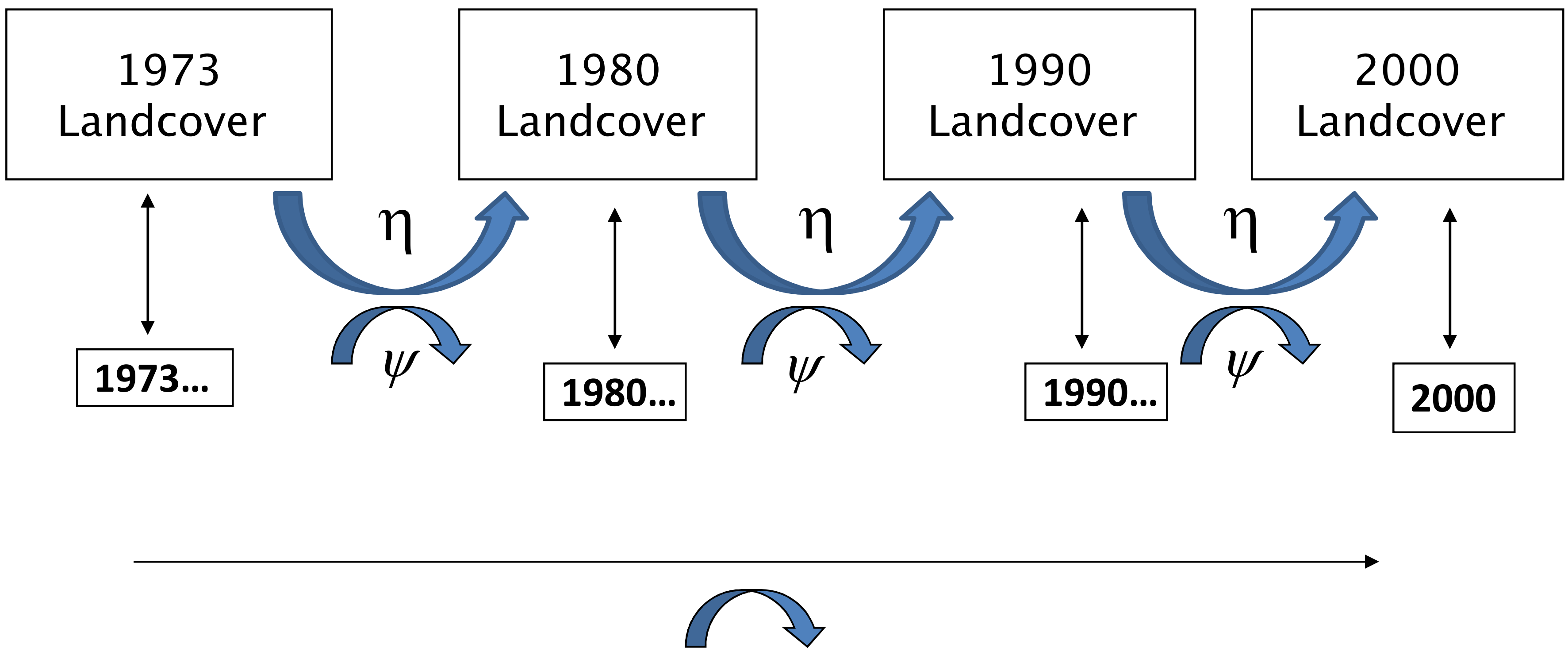


- We do not focus on the relationship between occupancy and habitat directly (e.g., niche-envelope), but on the relationship between habitat and Pr(ext) and Pr(col).

Species Distribution Patterns are functions of occupancy-based vital rates

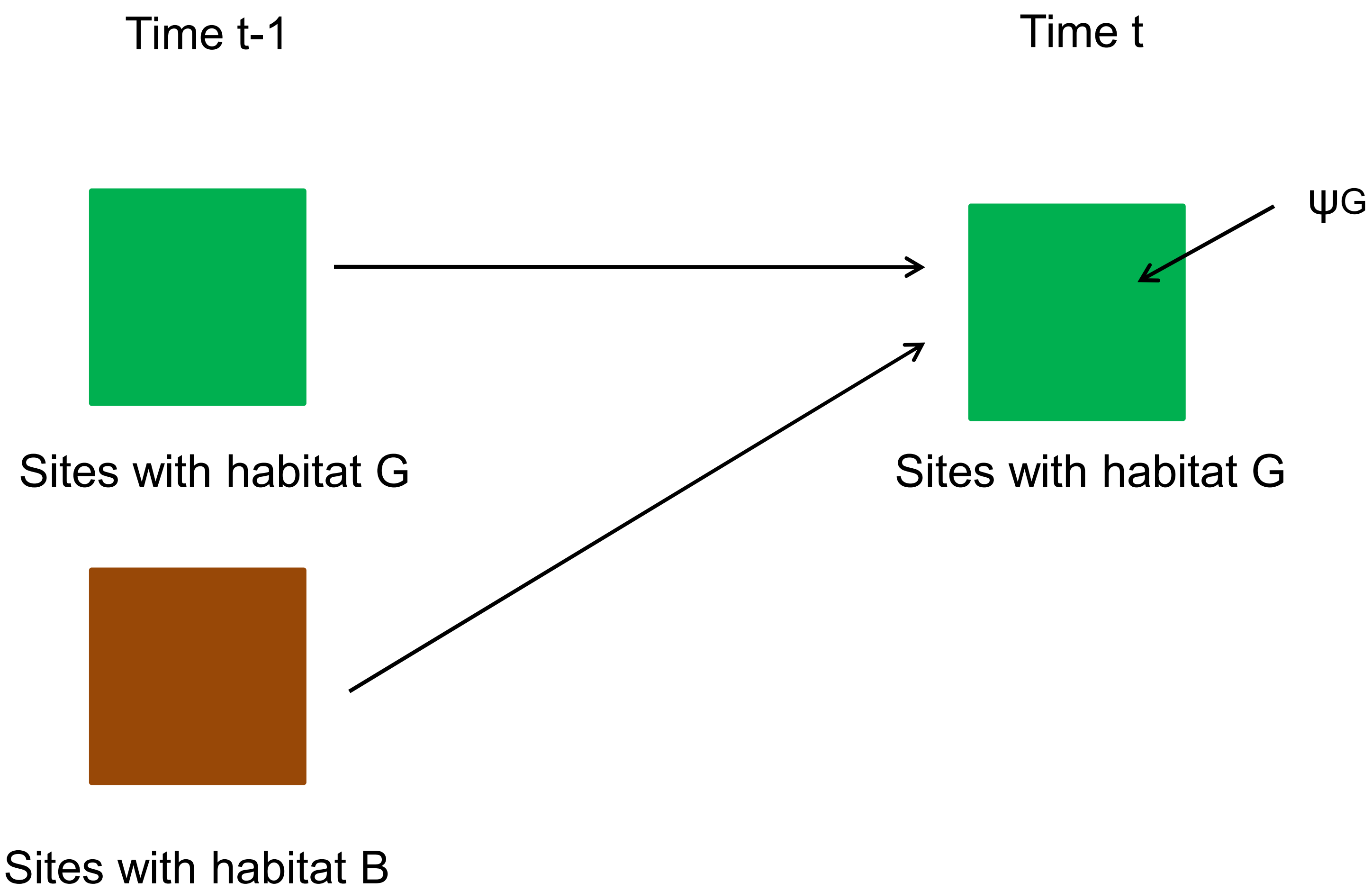


Integrate Habitat Dynamics and Climate…

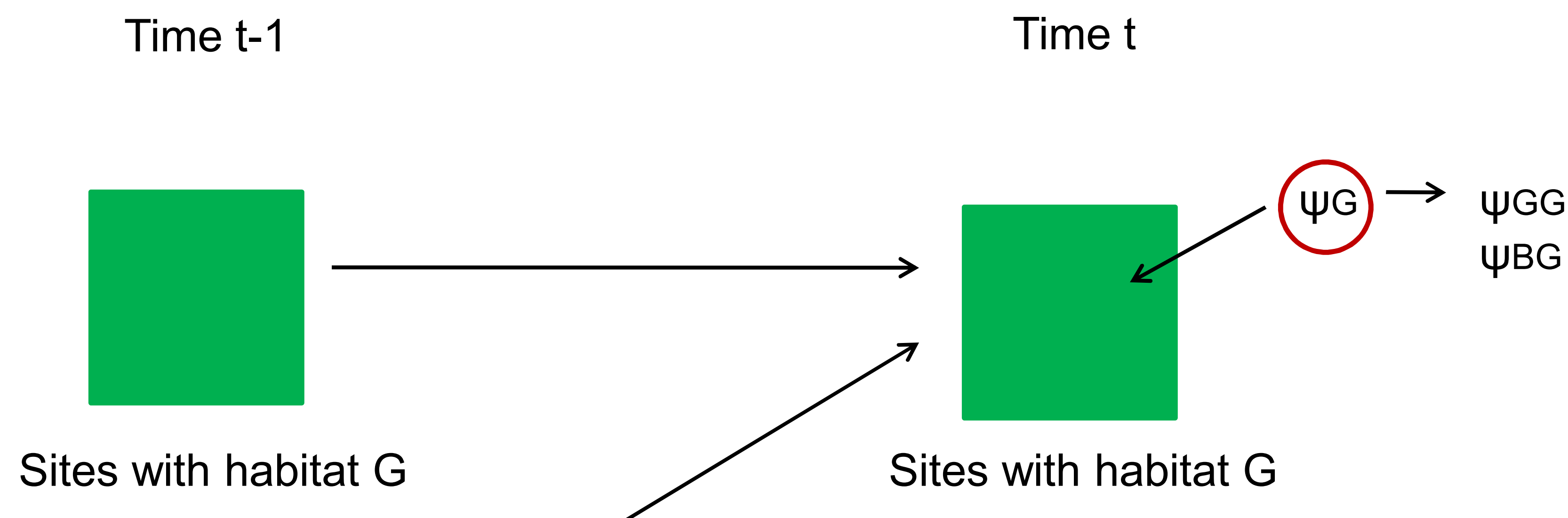


Patch occupancy conditioned (given) on what the habitat does

Estimating parameters of avian dynamics as function of habitat change (management and/or climate)



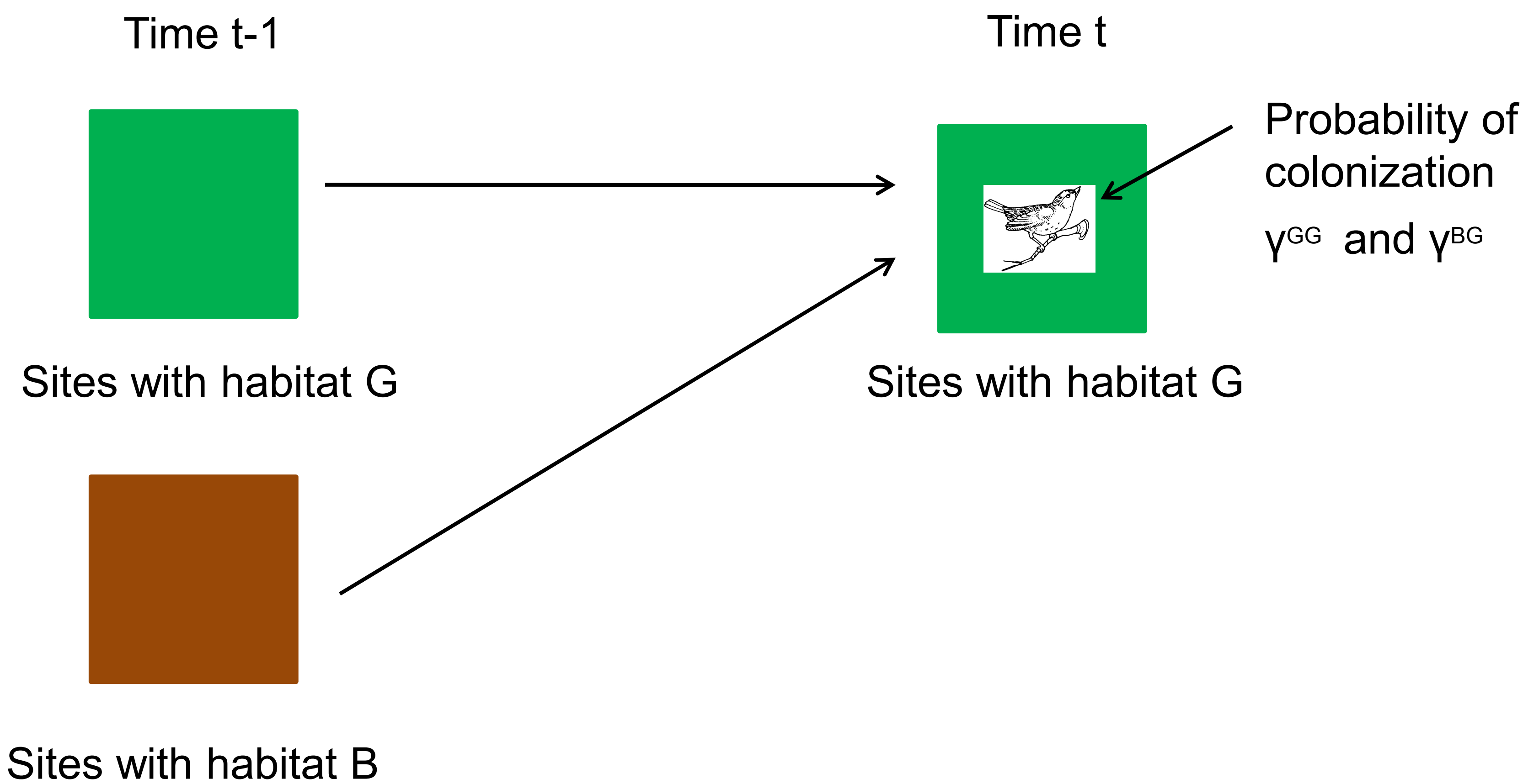
Estimating parameters of avian dynamics as function of habitat change (management and/or climate)



Incorporates habitat dynamics to occupancy

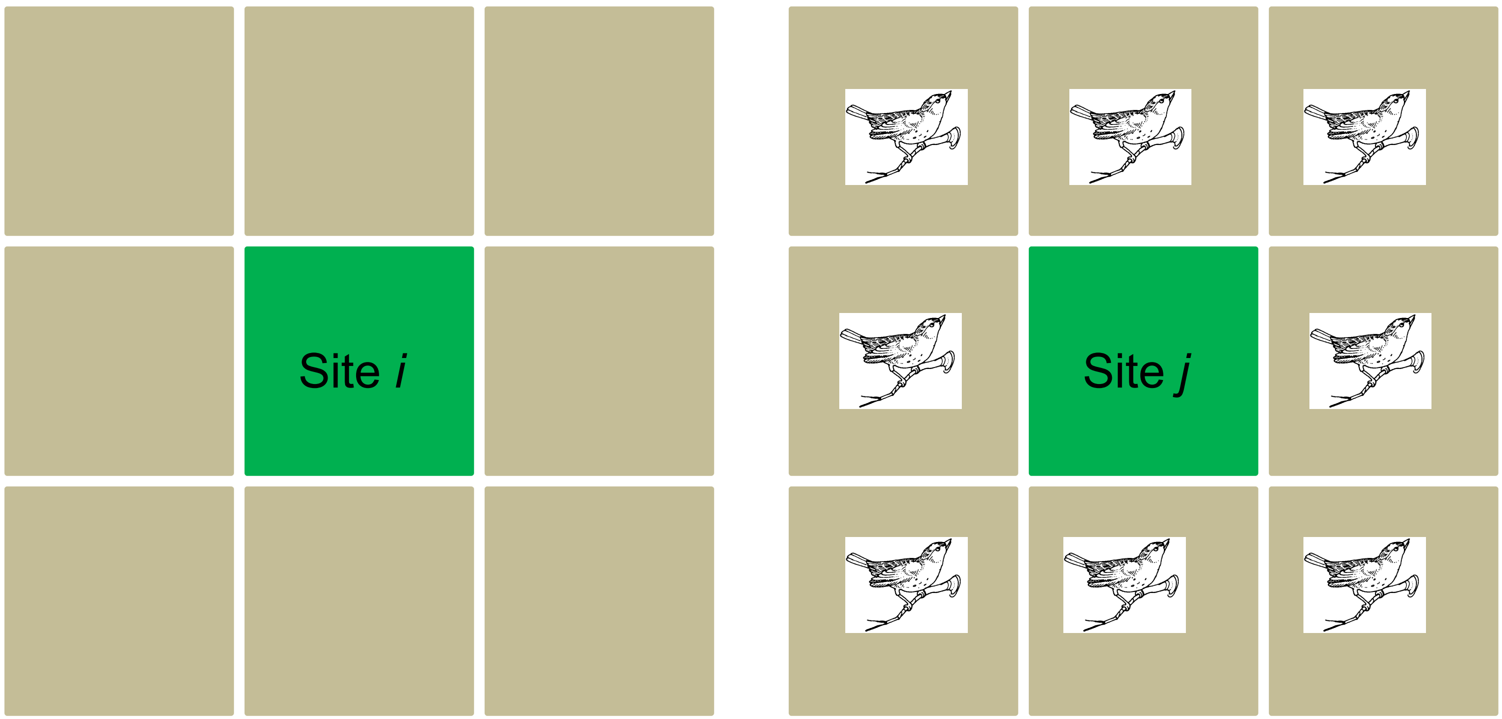
Notion of resilience or adaptation : how species react to habitat change. Very important for both management and prediction of climate/habitat change.

We can go further in understanding the process :



Occupancy at time t = f(extinction, colonization, occupancy at time t-1, and habitat transition)

Extinction and colonization influenced by occupancy of neighboring sites...



Range Dynamics NA Landbirds

- Treat Climate Change as a scientific problem

- Basic objective: Test hypotheses about avian range dynamics as function of climate change and other relevant macroecological covariates.

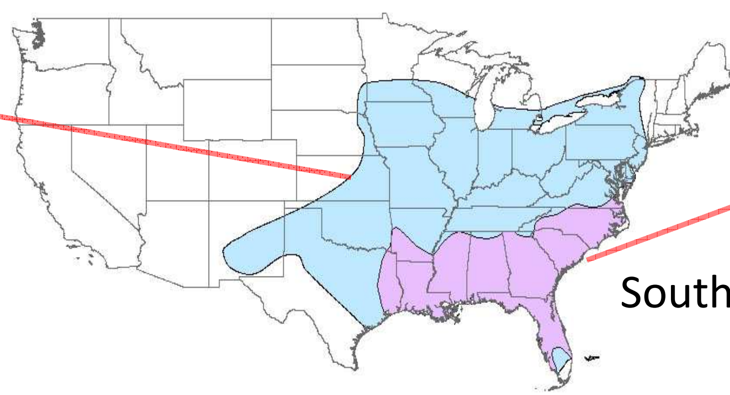
- Posit hypotheses and associated testable predictions about vital rates (probabilities of local extinction and colonization) as functions of;
  - Neighbor effects (occupancy of nearby locations)
  - Climate change
  - Land use change
  - Location within overall species range

Patch Dynamics and climate indicators

We asked
a) which climate indicator accounted for most variation in extinction rates?
b) whether support in the data would be stronger than for RE models?

<u>Non-breeding mortality</u>
Frost Days
Below Freezing Days
Hurricanes
Insect Thermal Thresholds

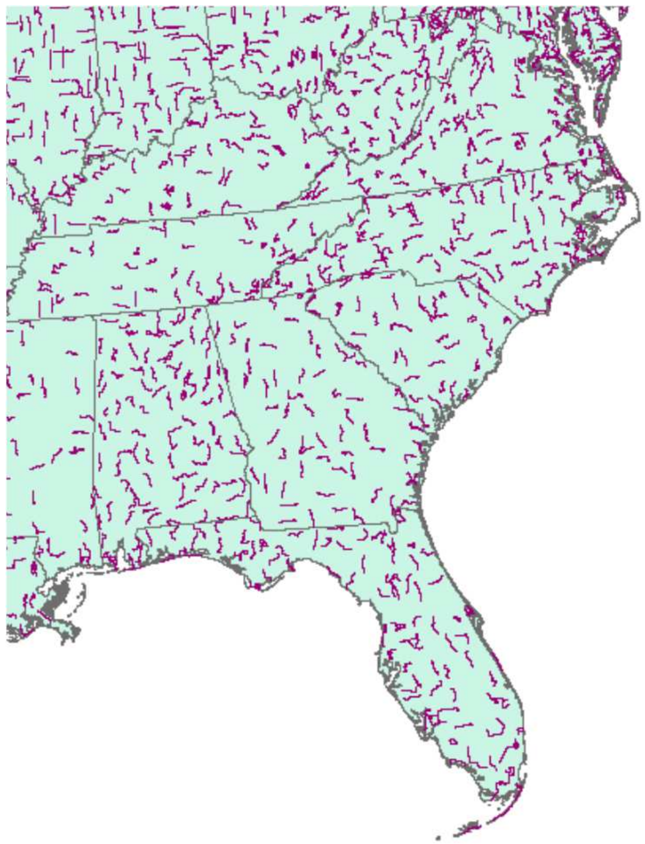
Focal Species



South-centric

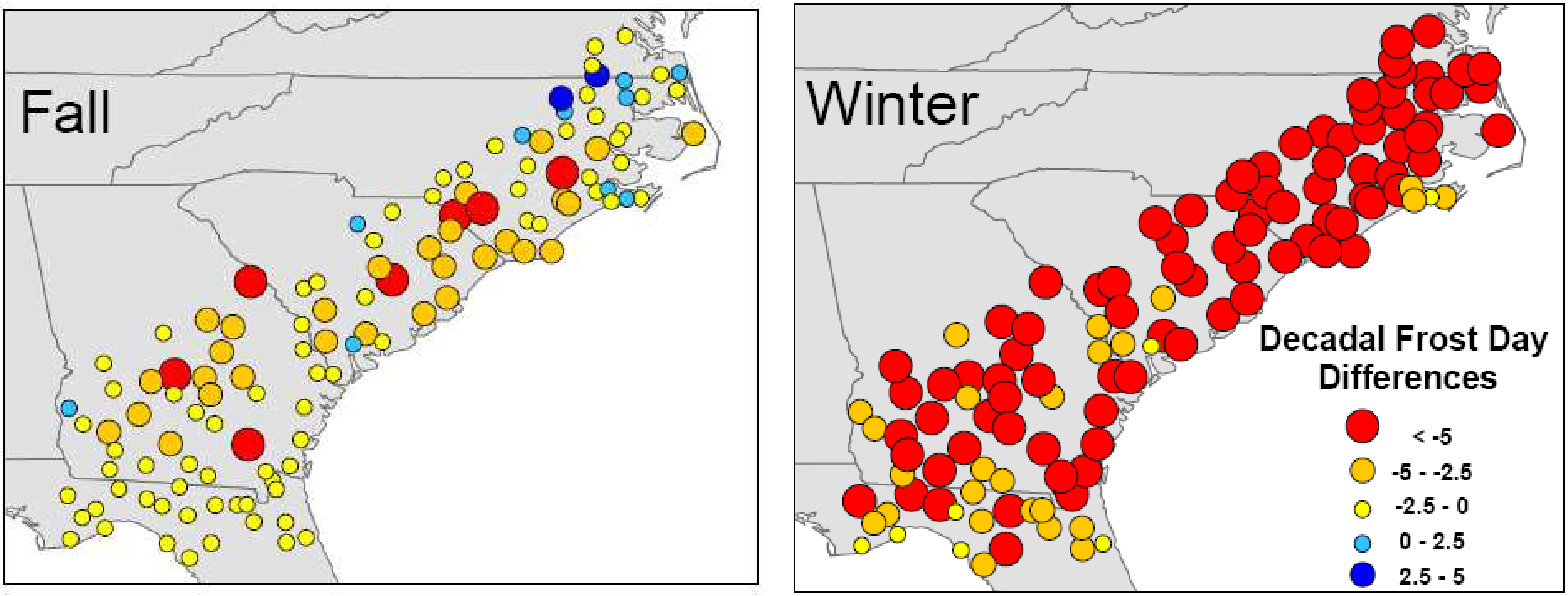
Spatial and Sampling Framework

- Use of Breeding Bird Survey data dictate spatial sampling for birds,
- Habitat/land use assigned to all spatial units in defined area using remote sensed data.

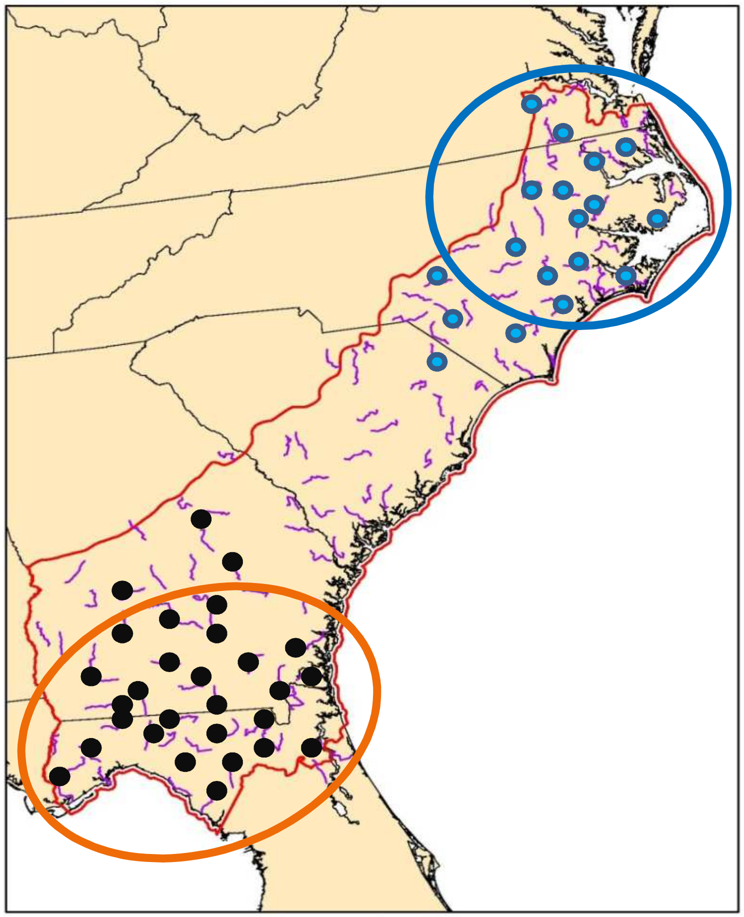


South Atlantic Coastal Plain

Consistently warmer in Winter than in the Fall



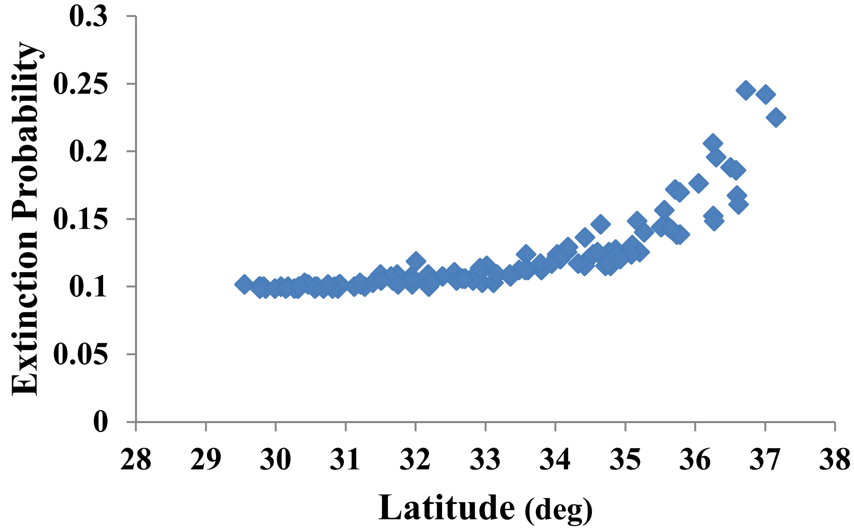
Patch Dynamics and climate indicators
Predictions

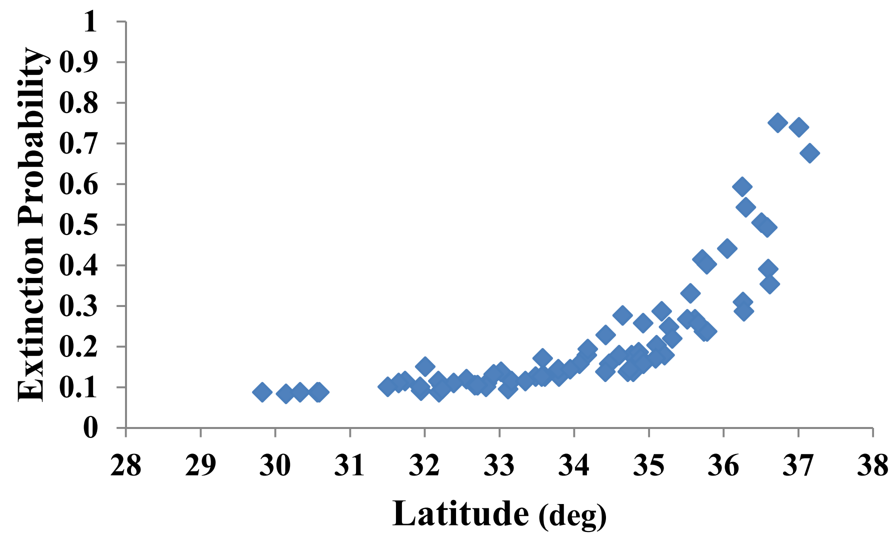


- Local Extinction (BHNU)
  - Increase with No. days below freezing
    - North-South gradient (strong)
  - Decreasing trend in extinction prob.
    - increasing temperature

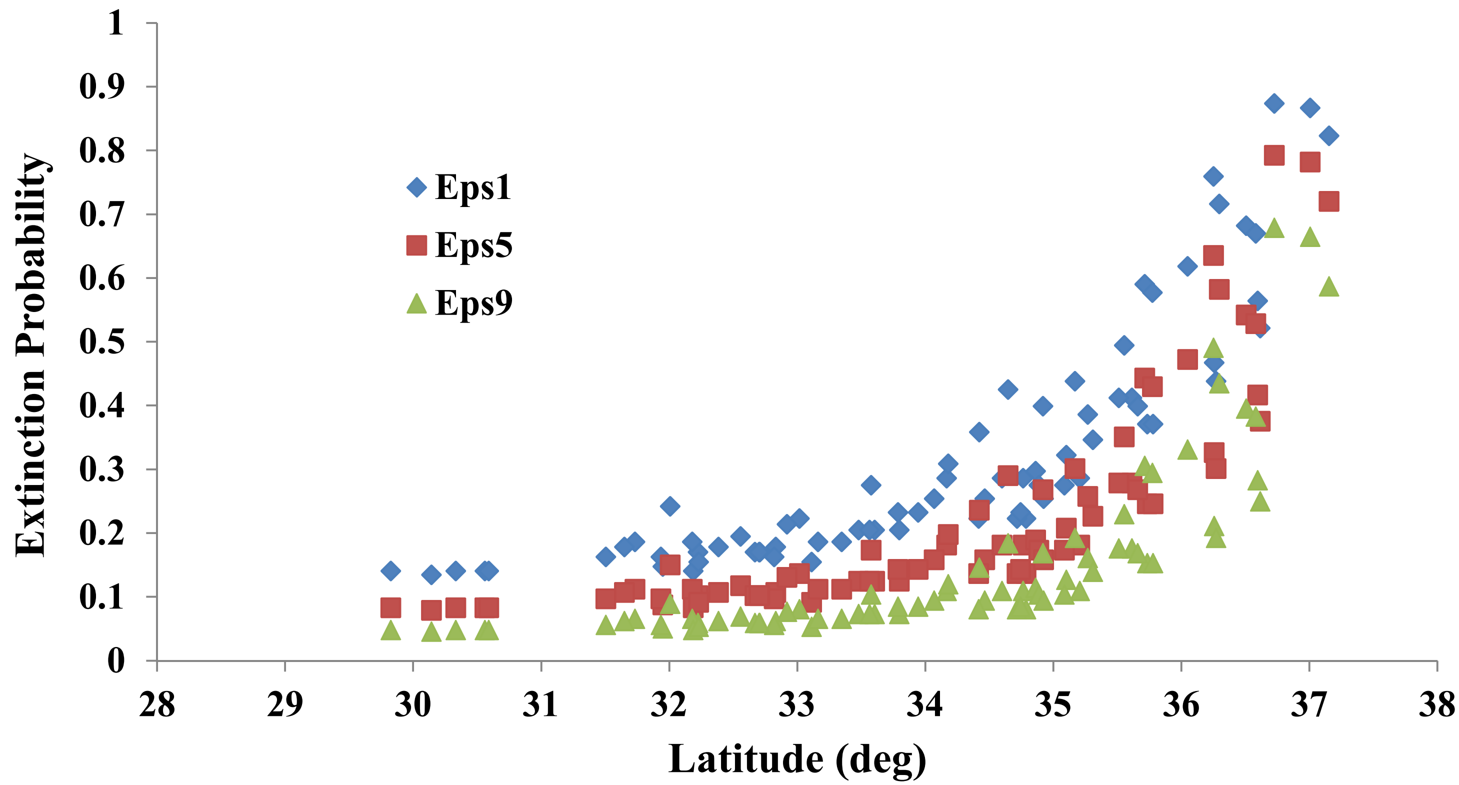
- Local Extinction (RHWO)
  - Weaker relationships
    - Wider distribution

Probability of Extinction as function of average days in Winter below 0°C (1990-99)

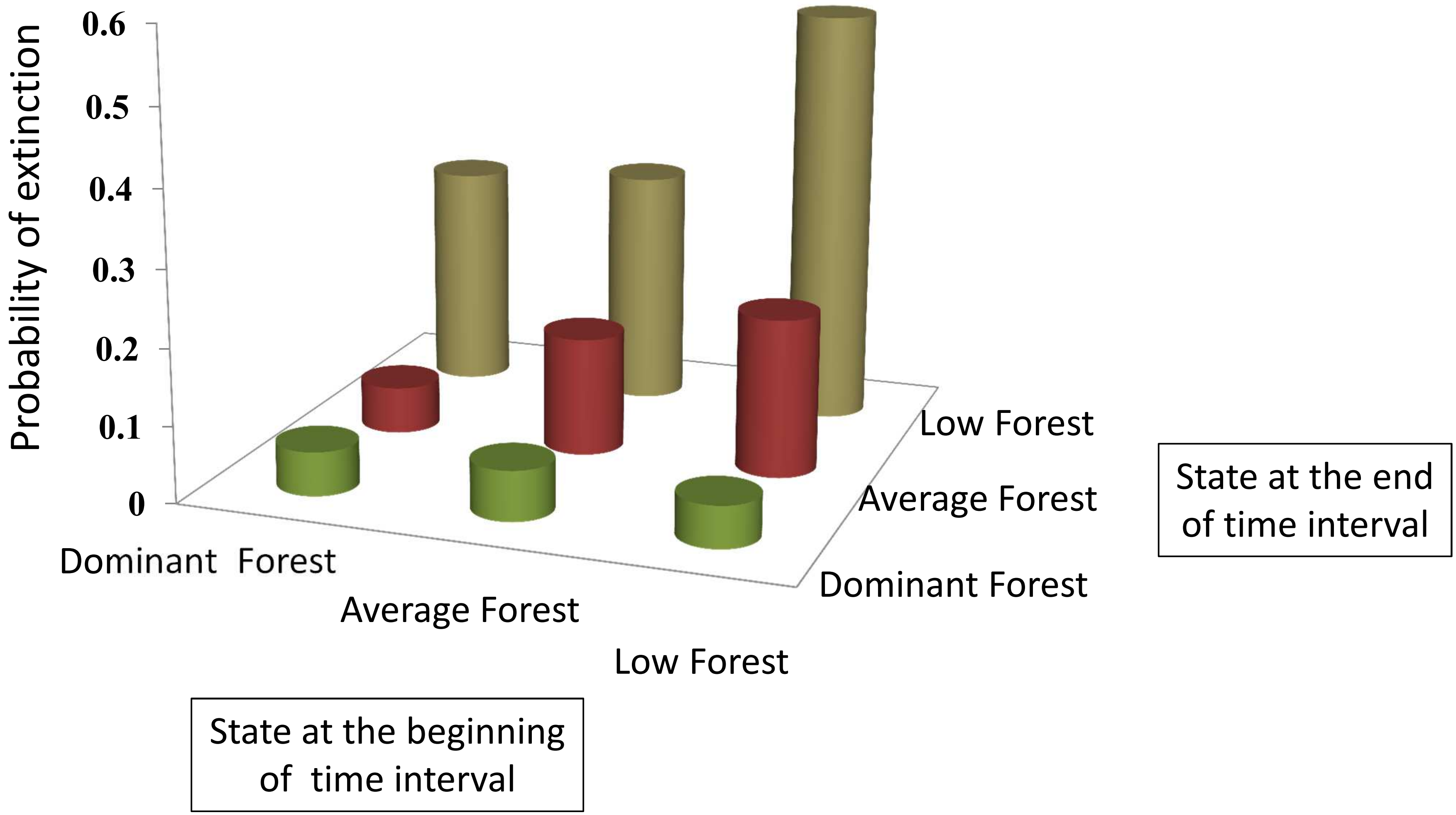


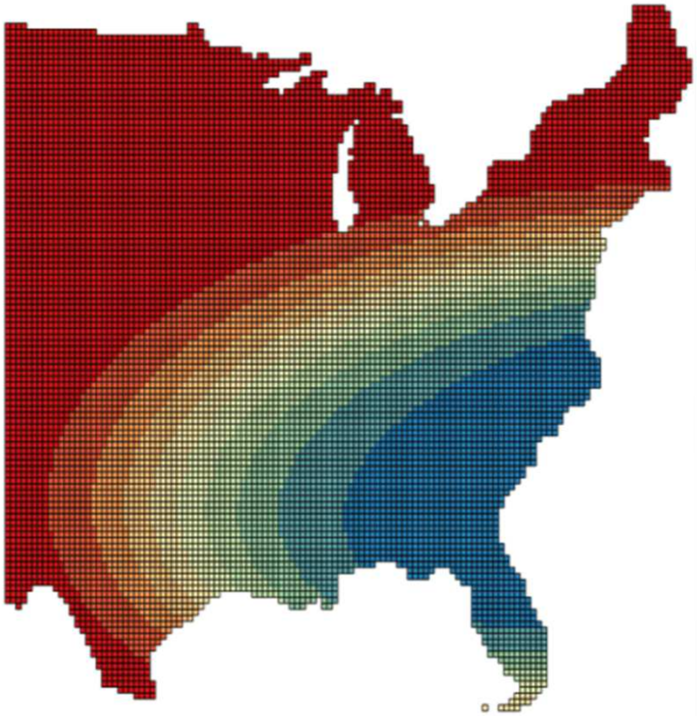


Probability of Extinction for BHNU as function of linear fit and average days in Winter below 0°C (90-99)

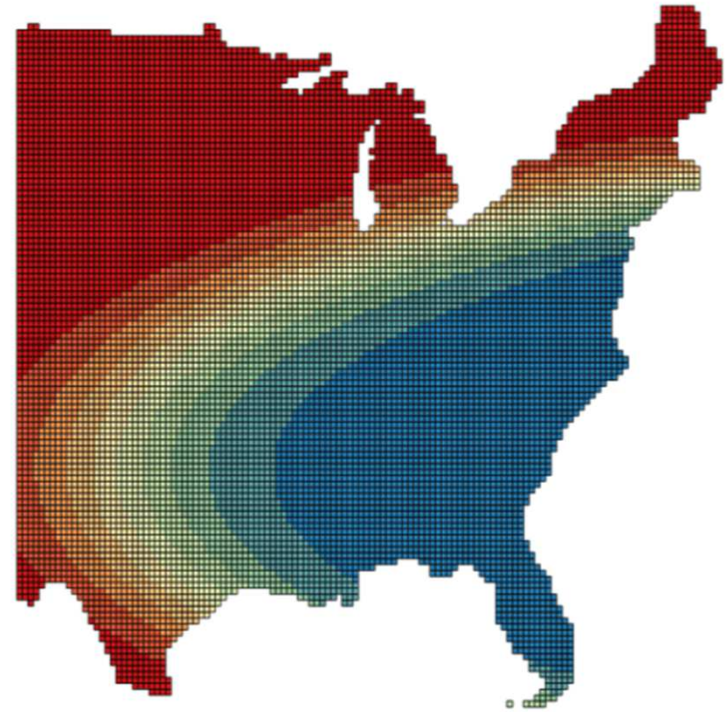


Red-eyed Vireo



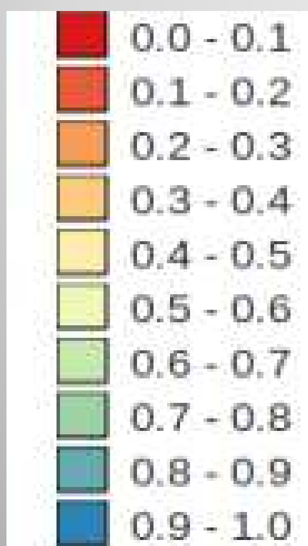


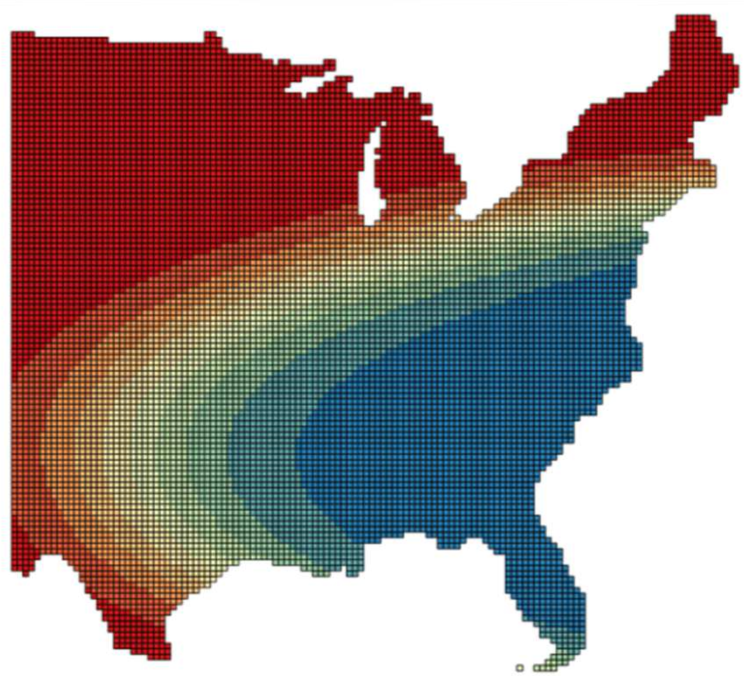
1985-1994



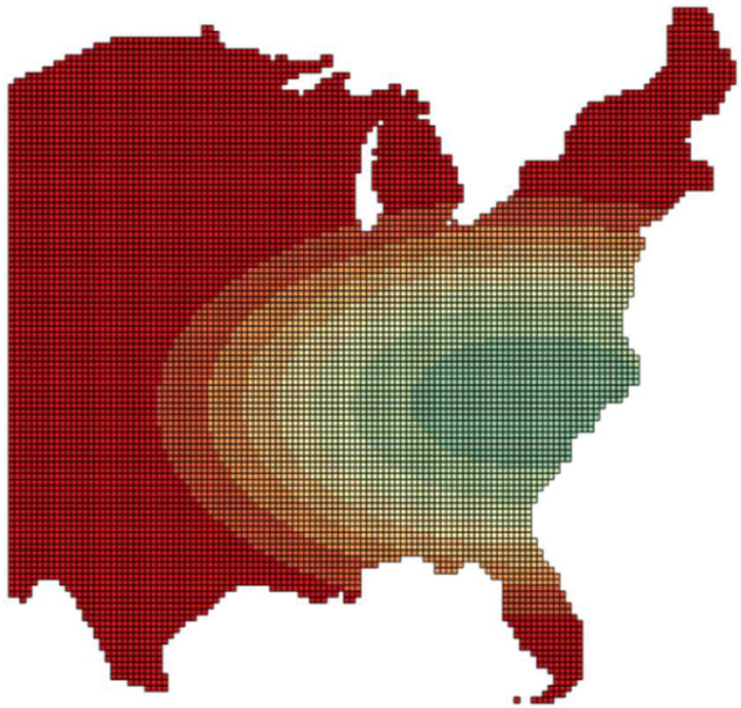
1970-1979

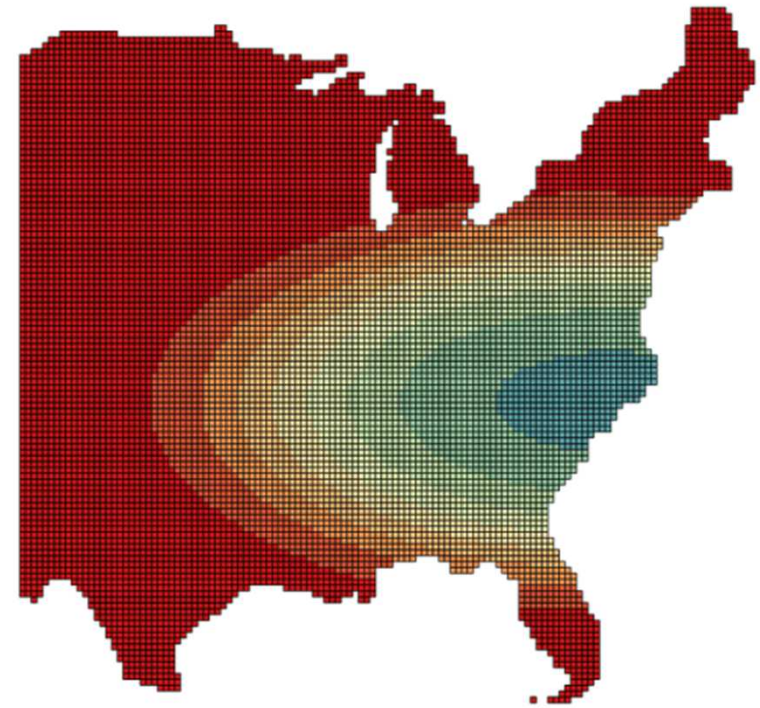
2000-2009





Carolina Wren- Probability of Occurrence





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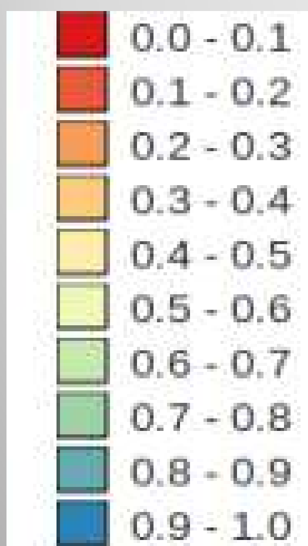

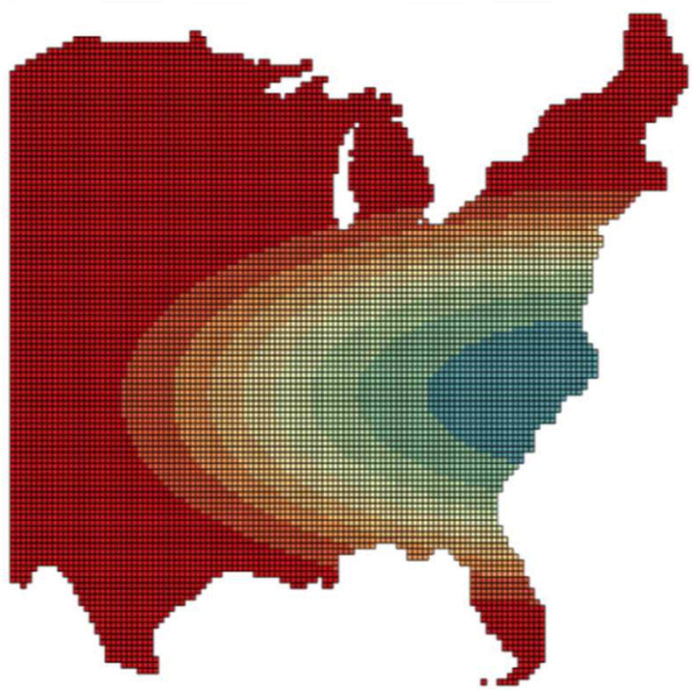

Acadian Flycatcher – Probability of Occurrence

Summary Points

Dynamic Species Distribution Models

- Occupancy represents the state variable of range dynamics, and extinction and colonization are the underlying vital rates governing the process of range change, providing a basis for defining expressions of population persistence.

  - Land cover dynamics is needed to unravel the effects of land use change versus climate change.

- Inform Decisions – states, actions, functional form for transitions, assess trade-offs…

Thanks

Questions?